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FLAME STUDIES: Methods and Results

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• IN RECENT YEARS efforts have been directed toward studying flames; their development and characteristics have received special attention by the steel industry. Simple industrial methods are available for observing flame development in furnaces. Also, more complicated methods were developed, such as periscopes for observing the interior of furnaces. Models are generally used for studying the effect of changes in burner and furnace construction. Considerable experience has been obtained regarding the construction and operation of such models. Studies of Siemens-Martin furnaces (open-hearth furnaces) are briefly described. Work with glass melting tanks is covered in greater detail.

From 1937 to 1940 this journal [*Glastechnische Berichte*], presented articles on studies of glass-melting tanks in order to acquaint glass technology with a field of work which promises decisive information on furnace construction; namely, the science of flames, also known as pyrology. The latter word has been coined to give a name to the field which is in keeping with our times.

The results of the earlier work described gave information concerning the construction of burners for side-fired and end-fired tanks with producer-gas heating. The studies agreed with the work of Rummel[1] but gave information for only a part of the field. A complete survey regarding the flow of flames in glass-melting tanks would require a very extensive investigation which, until now, has not been made.

The people in the English steel industry have made extensive use of Rummel's heritage. They completed thorough studies of flow-processes in open hearth furnaces and drew valuable conclusions, as evidenced by the work of Chesters, Thring, Newby, Halliday, Leys, Leigh, and many others.

Fig. 1. Photograph of a flame taken through a burner mirror.

The flow processes are only a portion of the phenomena which are significant for the effectiveness of flames. Heat development and heat transfer by flames to the charge and furnace walls are equally important.

Significant work has been carried out along this direction during the post-war years. The center of all these studies is the experimental station at Ijmuiden, where English, French, Dutch and Swedish specialists work together. Since these investigations are also directed toward open-hearth furnaces, knowledge regarding the processes in this type of furnace has grown considerably in the last decade.

No such similar survey exists for glass-melting tanks, despite the fact that glass technologists recognized the significance of such work very early and made isolated

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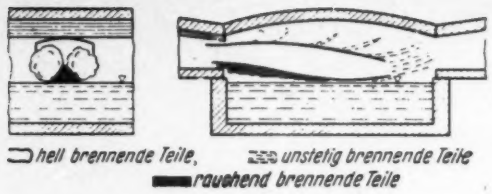

Fig. 2. Sketch of a flame in a cross-fired tank.

Hell brennende Teile: Bright burning portion.
Unstetig brennende Teile: Unsteady burning portion.
Raucked brennende Teile: Smoky portion.

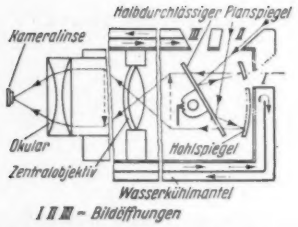

Fig. 3. Periscope for observing flames.

Kameralinse: Lens of camera.
Okular: Ocular.
Zentralobjektiv: Center objective.
Hohlspiegel: Concave mirror.
Wasserkühlmantel: Water-cooled jacket.
Halbdurchlässiger Planspiegel: Semi-transparent plane mirror.
Bildoffnungen: Openings.

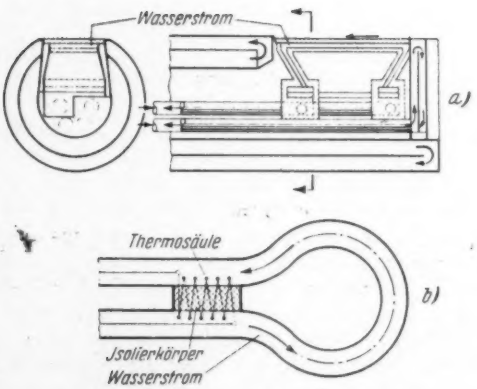

Fig. 4a. Heatflow meter after Baulk and Thring.
b. Radiation intensity meter after Eichert.

Wasserstrom: Stream of water.
Thermosäule: Thermopile.
Isolierkörper: Insulator.

measurements, especially in England, beginning in 1941; also in Russia and Japan and, as mentioned earlier, in Germany.

The work carried out by the steel industry is valuable to glass technology because it shows what measuring techniques can be used successfully. The work also enables one to determine the results which might be expected. Therefore, it is timely to examine more closely the processes of flame development in glass-melting tanks as a result of the basic information which has been gathered in the steel industry during recent years.

In order to show what material is available today for the study of flames, the author presents the results of the most important work completed up to the present time on open-hearth furnaces and glass tanks.

But first we shall present a review of the type of problems which must be solved, and the experimental procedures used.

Problem

In every industrial heating operation (for example, heating a glass tank with gas) there are three important groups of processes:

1. Flow of fuel and air and mixing the two;
2. Reaction between fuel and air;
3. Heat transfer from the reacting or combusted materials to the charge and the furnace.

The goal of all work for better control of the combustion processes in furnaces is:

1. To utilize the available energy as completely as possible;
2. To limit the action to a desired space;
3. To assure an effective heat transfer.

In general the following more concrete questions are dealt with:

a) Length of flame.
b) Disturbance of the combustion gases in the furnace chamber and in the burner (flame position).
c) Combustion and temperature along the flame path.
d) Radiation characteristics of the flame along its path.
e) Heat transfer by radiation and contact.
f) Furnace atmosphere, especially in the regions where the flame touches the charge.
g) Effect of flame on furnace refractory.
h) Structure of the flame and mechanism of mixing.
i) Chemical processes of combustion; physical changes in unburned fuel particles.

a) The length of the flame is a very important characteristic in furnace operation. One is usually satisfied in production to set the flame length equal to the region of visible combustion processes. Since the reactions at the beginning zone of the flame call for greater attention than at the end of the flame, the abbreviated definition for flame suffices. No simple alternate method is available. In the studies by the author the flame length was defined as the region in which 95 per cent of the combustion takes place.

b)-d) The flame position and the combustion process, next to flame length, are the most important criteria for evaluating a flame. The description of the flame, with the aid of velocity regions, mixing, combustion and temperature zones, is essential to every discussion on firing

technique. The various qualitative and quantitative methods help in the treatment of these questions.

e) Radiation from a gas flame, that is, from a semi-transparent medium, is physically difficult to deal with. Consequently, technical approximation methods are used for the most important applied cases. In the determination of heat transfer by convection one has to make use of analogous work carried out at lower temperatures since no special work has been done in this field.

f) It is slowly being recognized that the furnace atmosphere which acts upon the charge varies from point to point and frequently is of entirely different composition from the waste gas which one finds in the outgoing side of the generator. In many furnaces, the atmosphere changes locally, and also periodically, from an oxidizing to a strongly reducing one.

g) The destruction of portions of refractory by impinging flames plays an important role in open-hearth furnaces, while in glass tanks, glass attack on refractory material is of greater interest. With increasing use of fusion-cast blocks for tanks and the greater durability of such structural materials, the attack by flames (gases) on refractory walls becomes important for the glass-melting tanks.

h) The wide application of model experiments and Rummel's thesis, "mixed = combusted," lead one to conclude that statistical average values of mixtures observed in model experiments describe the combustion process. Since in practice flames, especially in large melting units, consist of individual balls, or cells, of gas and air which react only at their points of contact, the average mixing precedes combustion. It would be extremely valuable to study thoroughly flame structures and their conditions for formation.

i) The treatment of chemical reactions between combustible matter and air takes a back-stage stand as compared with flow problems. The statement, "mixed = combusted," appears to make it unnecessary to deal with the reaction mechanism of combustion. However, one must not overlook the fact that this basic rule holds only for gases, while soot particles or droplets of oil also burn gradually in the presence of air since these substances must first be converted to the gaseous or vapor state before they can react with air.

Method For Observing And Investigating Flames

The enumeration of the problems may give the impression that these questions, which are so important to the practitioner, can be solved only with expensive scientific means, and that the production man cannot achieve much by empirical methods. However, if one deals more closely with the subject, one immediately recognizes that simple tools are available for making observations in production—tools that are seldom used. In a purely practical way one can achieve substantial progress in the knowledge of combustion processes and can gain important information regarding burner construction.

Qualitative Observation of Flames

In all glass works, the melter, superintendent and factory manager convince themselves by visual inspection of the position and course of the flame in a furnace. But

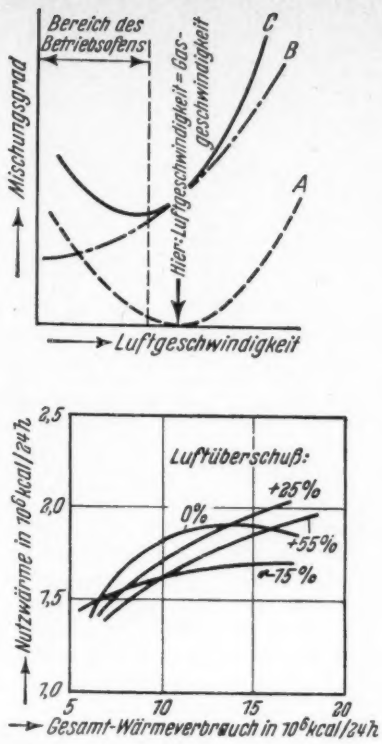

Fig. 5. Results of hot-model studies. (Top) Influence of air velocity on mixing at constant gas velocity. A: Mixing action due to relative gas-to-air velocity; B: Mixing action due to absolute flow rate; C: Actual mixing action.

Mischungsgrad: Degree of mixing.
Luftgeschwindigkeit: Air velocity.
Hier Luftgeschwindigkeit = Gasgeschwindigkeit: Here air velocity = gas velocity.

(Bottom) Change in useful heat as a function of heat input and gas/air ratio. (Cross section of gas duct 0.0167m², air duct 0.0161m², heating value of gas, 3030 kcal/Nm³, pressure in crown 0.508 mm. water column).

Nutzwärme: Useful heat.
Gesamt-Wämerverbrauch: Total heat consumption.
Luftüberschuss: Excess air.

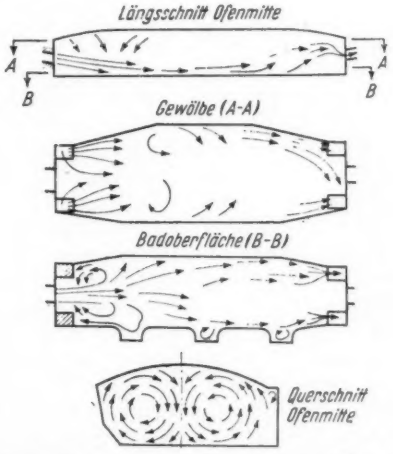

Fig. 6. Convection currents in a Siemens-Martin furnace (system Maerz) under the crown, above the melt and in two vertical sections (after Thring and Hansen).

Längsschnitt Ofenmitte: Longitudinal section, center of furnace.
Gewölbe: Crown.
Badoberfläche: Surface of melt.
Querschnitt Ofenmitte: Cross-section, center of furnace.

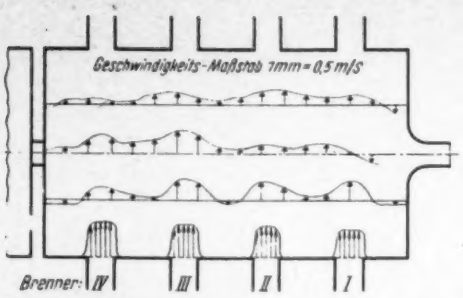

Fig. 7. Horizontal component of velocity of air in a plane 1.37 m. from the floor of the tank. The cold tank was used as a model; the air velocity represents that of the radiant flames.

Scale: 1 mm. = 0.5 m/second.

they very rarely will decide to maintain a record of certain production conditions in the form of sketches and to test them by referring to such records. The information could, for example, show how changes of the gas-air ratio or of stack-draft affect flames. Also the effect of structural changes of the burner should be followed with sketches. This has generally not been done in the past.

This method is quite rough, but its significance must not be underestimated when considering the difficulty of making technical observations in a furnace. In a sketch of the type shown in Fig. 1 there are a number of flame characteristics, especially its length, its position over the glass bath and its upper boundaries. If one makes additional observations from the side by looking through both burner mirrors, one can get some idea of the width of the flame.

The various colors in the region of the flame also give important information. Regions which are turbid or grey are indicative of reducing flames, while bright regions indicate oxidizing flames. These observations can also be included in flame sketches.

The observations are simplified if a special glass* is used which filters out sodium radiation. This has a negligible effect on heat transfer, but must not disturb the picture.

The free-hand sketches can be supplemented by photographs. Usable pictures of flames can be obtained without great photographic expenditure as long as the objective is protected from radiation by means of a heat-absorbing filter. Photographs taken through both burner mirrors as well as through the side give valuable information. Fig. 2 is an example of such a picture. The method can be improved by making use of the principle of infrared photography in studying the distribution of radiation intensity.

Cinematography also is a valuable aid. Chesters in England has used film with great success. He was able to record the behavior of flames in open-hearth furnaces. By introducing materials which are strong smoke generators in the burner it was possible to show clearly the flow patterns. Sudden additions of salts produced colored clouds, which enable one to measure flame velocities and observe mixing processes in the flame.

* For example, Alutherm No. 6 manufactured by D.S.A.G. (German Mirror Glass Co.) in Grünenplan.

The effectiveness of these aids can be still further improved by making use of a television camera so as to observe the processes in the furnace from a remote point; for example, a control room. A scanning periscope, as suggested by Burns [29], may also be used to increase effectiveness. (See Fig. 3).

It should be added that a cathetometer was used for making exact determinations of the flame boundaries.

Evaluating Course of Flames by Quantitative Determination of Single Characteristic Parameters

In addition to making observations on the appearance of flames, there are numerous possibilities for determining the course of flames in production furnaces by measuring single characteristic parameters. Gas analysis is at the top of the list. By means of water-cooled probes one can take samples from the furnace chamber and from the ports and, if required, one can obtain average values as a function of position and time during such sampling.

From the analysis of the sample, or from a larger number of samples taken at various positions, it is possible to draw conclusions regarding combustion. If this testing procedure is supplemented with automatic flue-gas testing equipment, which can be used in place of the simple Orsat-apparatus, it is possible to make more complete studies. In this way one can obtain without excessive expenditure of time a picture of the course of mixing and combustion in a furnace.

The velocity distribution in a furnace can be determined by measuring the pressure head with water-cooled probes.

An additional measurement which is important in this analysis is the temperature measurement of the section of the furnace which is irradiated by flames. From the temperature distribution of the furnace walls and the charge one can draw conclusions regarding the radiation characteristics of the flame. The flame temperature itself is difficult to measure. One is usually satisfied with average values over the range measured with the optical pyrometer. In the case of weakly-radiating flames this type of measurement is complicated. An exact determination of the temperature contour of a flame, which is conceivable by calorimetric means, has thus far not been successful because of technical difficulties.

The use of calorimeters which measure the total radi-

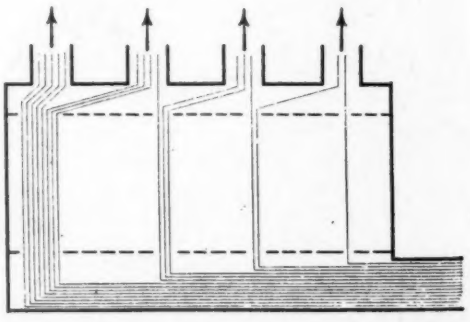

Fig. 8. Flow distribution in a cold regenerator chamber, measured on a production furnace.

ation of a flame has been more promising and effective. The work of Baulk and Thring[3], which deals with heat-flow measurements between flames and molten steel by means of a special probe, is informative. They used a calorimeter (Fig. 4a). It measures the radiant heat which strikes the calorimetric probe, such as, for example, the radiation from the space over the melt in an open-hearth furnace.

As a stream of water flows through the probe, its velocity or amount is measured. The temperature rise of the water stream for a known absorbing surface is a measure of the radiation of the furnace chamber, or when the probe is turned through 180°, the radiation of the melt.

The difference between the two represents the amount of heat transferred by radiation. Despite the large fluctuations to which the flame radiation is continuousl being subjected, the apparatus enables one to obtain average values over a period, for example, of 10 minutes, which are useful.

The author had at his disposal in the last few months an apparatus designed by Eichert[20] which is similar to Thring's heat flow meter. It is shown in Fig. 4b. In contrast to the previously mentioned apparatus, the prob absorbs radiation from all directions and consequently cannot be used for the determination of heat flow. However, it enables one to observe periodic and local distributions or radiation intensities which can be useful for many purposes. Additional devices of various construction are being thoroughly tested at the Ijmuiden testing station. They gave useful information on temperature distribution and radiation.

MODELS FOR STUDYING FLAMES

Cold Models

Since a quantitative study of flow patterns and combustion contours in furnaces is very laborious, one relies on models for treating such processes, especially for evaluating the effect of structural changes. Comprehensive treatments on the development of the techniques used are given by Chesters[27] and Thring[31].

The conditions of similarity for model presentation of flow and mixing problems encountered with flames are not difficult to meet. Frequently geometric similarity and approximate agreement of Reynold's number are

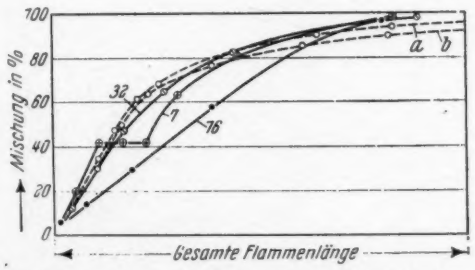

Fig. 9. Mixing in a burner without horizontal tongue (a) and with horizontal tongue (b) after Kruszewski. For the construction of a and b, compare Fig. 10. The curves 7, 16 and 32 give the mixing process as based on production data by the authors [37, 38].

Mischung: Mixing.
Gesamte Flammenänge: Total flame length.

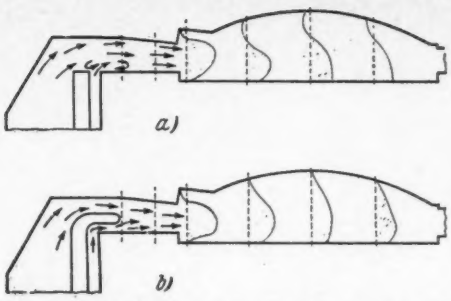

Fig. 10. Flow distribution in tanks with burners of varying construction. Individual curves show the velocity distribution in the planes shown by cross-hatched lines. Backflow in model a.

sufficient. Ascensional forces play a role; for example, in chamber studies one must fulfilll still another condition of similarity. The role of buoyancy in ports and in furnaces is a minor one, so that it can be neglected in simulative studies.

The most difficult point in model presentations of flames is the simulation of volume increase in the products of combustion which is brought about by the heat evolution during burning. One can attempt to simulate these processes by actually permitting combustion to take place in a model (hot model). Such models, however, are expensive. They are used only when studying radiation processes, and when limited to cold models for studying flow and mixing processes.

According to the work of Thring and Newby[25] such a model reproduces flow processes exactly, provided the flame is regarded as a free jet. This is generally the case for the first half of the flame path in a furnace.

The above assumption does not completely hold for the processes inside producer-gas ports. Here if one works with cold models one must either live with the deviation from the exact model similitude or attempt to alter the cross-section of the flame in relation to the exact scale of the model in such a way as to equalize the expansion of the burning gases. By taking these limitations into consideration, one is able to study the processes of mixing and flame propogation for individual burner constructions in the laboratory by means of cold models, and one can thereby obtain important basic data for furnace construction.

One generally works with models scaled down 1:10 to 1:20. Some English glass and steel specialists use the production furnace itself as model[19, 32] prior to putting the furnace into operation. This is accomplished by producing with a blower an air current whose velocity fulfills the Reynolds conditions of similitude.

The velocity contours in the furnace can be quickly measured with an anemometer. This method has the great advantage that it takes into account all geometric effects such as inaccuracies in construction, and roughness. Since furnaces are generally only available for a short time for measuring purposes prior to turning them over to production, it is necessary to have everything ready for model tests.

Such studies, which stand between production and model observations can give excellent information re-

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Corning's New Apparatus Plant at Big Flats

Joseph C. Littleton, left, manager, Corning Glass Works apparatus plant, and Herman H. Schrickel, Sr., "Dean of American lampworkers," who served as plant manager from 1929 to 1955.

• THE WORLD'S LARGEST PLANT devoted to the fabrication of laboratory glassware was officially placed in production by Corning Glass Works on June 14, 1958.

Situated eight miles east of Corning, N. Y., the plant houses the largest group of lampworkers ever gathered under one roof. Other highly skilled employees work as glass etchers, engravers, latheworkers, grinders and toolers. Altogether, over 600 persons are employed, according to Joseph C. Littleton, plant manager.

The apparatus plant is located on a 46-acre site and, within its 176,000 square feet, includes a large manufacturing unit, administration offices, a warehouse and an employe cafeteria seating 100. The manufacturing area, large enough to encompass four football fields, is 625 feet long by 280 feet wide.

Over 10,000 different pieces of laboratory apparatus, ranging in complexity from simple test tubes to automatic burettes requiring 61 separate manufacturing operations, are fabricated here. In its vast system of product files, the Corning plant keeps cards on 15,000 different items that have been made as special pieces.

To handle any one of these many operations, Corning engineers designed the plant around a predetermined "flow system" that was, in large part, the result of actual brainstorming sessions conducted with the people who work in the plant. The goal: placing proper equipment in the right location to insure the most efficient processing, at minimum cost, of the thousands of items produced.

The achieving of this goal was met by many innovations within an industry that has been traditionally a "craft type" industry, where changes are usually slow.

In fact, many of the machines and processes in the Big Flats plant were developed under the skilled guidance of Herman H. Schrickel, Sr., who has often been called the dean of the American lampworkers. He served as apparatus plant manager for 32 years and saw the shop develop from an original staff of four men in 1921 to more than 500 in 1956 when he retired.

For example, beside each of the lampworkers and other skilled craftsmen who turn out some of the most complicated glass products in the world, there is a ground conveyor system. It rolls materials directly to each work station and, with equal ease and swiftness, carries away the product when the particular job is completed. Overhead another conveyor system, controlled by an electric eye, automatically picks up and deposits materials and parts at predetermined points.

The new plant uses an "order picking" system that enables stock clerks, using electrically operated trucks with lifts, to remove items easily and quickly which have been stacked to the ceiling, resulting in full utilization of the storage area and ready access to inventory.

Latheworkers (foreground) in Corning's laboratory apparatus plant at Big Flats, N.Y.

Offices of the foreman are located in the factory, rather than in the administrative wing of the plant, in order to provide on-the-spot trouble shooting and closer supervision of each operation.

The overall plant layout allows a steady, smooth flow of materials through the various manufacturing operations—from the unloading of the glass tubing and rod, at one end, to the loading and shipping platform for completed ware at the opposite end.

One of largest sealing operations performed by Corning. Six-inch glass pipe is mounted on special jig.

All the work stations—for sorting, fabricating, grinding, engraving, decorating, etching, staining—fall into this flow pattern. The end product moves to the point of packaging and shipping without lost motion, effort, or time.

When Corning first entered the laboratory apparatus field 43 years ago, it had no lampworkers, no fabricating equipment. It did have skilled gaffers who blew simple flasks, retorts and beakers out of a new type of borosilicate glass later to become well-known throughout the world as Pyrex brand glass.

In 1912, Dr. Eugene C. Sullivan, the founder of Corning's research laboratory (1908) discovered that by adding borax to the glass batch and increasing the silica content, the glass became much more heat resistant because of the lowered coefficient of expansion. Railroad signal ware and Pyrex brand ovenware were the first

Skilled lampworker fabricating special piece of laboratory glassware.

products marketed, but this new glass also had a by-product of immense importance to the nation.

Before World War I, the entire chemical world was dependent on Germany for the more complicated pieces of laboratory glassware. After the German supply was cut off by the war, Corning in 1915 started to turn out flasks, beakers, test tubes and other simple pieces.

Using its new glass, Corning was able to meet the need with laboratory ware of high chemical stability, maximum thermal shock resistance and high mechanical strength. The German-made ware never was able to recapture its former position.

Scientists began to demand more complicated pieces

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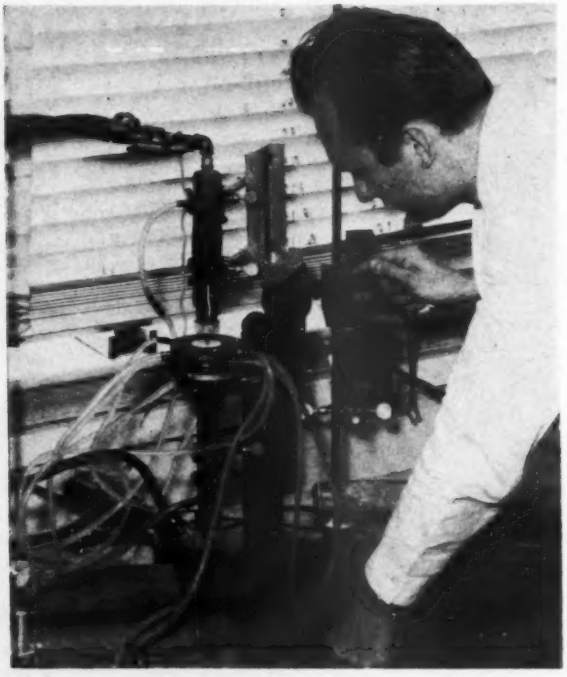
Inspecting laboratory apparatus, dipped in wax, before sending to engravers.

Grinding area of apparatus plant. Here, standard taper joints are prepared.

High-Temperature Measurements



Electric arc apparatus for studying processes in gases at temperatures up to 10,000°C at the National Bureau of Standards. Scientist is lowering the upper electrode to initiate the arc. Light emerges from slit between the two horizontal circular plates and is analyzed with a spectrograph. Carbon arc, behind scientist's hand serves as brightness reference.

• As in other fields of research, progress in the high-temperature program of the National Bureau of Standards has depended largely on the development of suitable instrumentation. In response to needs in critical areas of technology and in fundamental physics and chemistry, improvements have been made in many of the methods for measuring and generating high temperatures and for determining physical and chemical properties of materials at those temperatures. However, a great deal of additional work in high-temperature measurements must still be done in order to meet urgent needs in such fields as high-speed flight, rocket and missile development, and atomic reactors and power plants.

The basic instruments for measuring temperatures above 1000°C are the optical pyrometers that are calibrated at the Bureau by comparison with its standard pyrometer. This, in turn, is calibrated by observing a black body maintained at the freezing point of gold (1063°C), one of the primary fixed points on the International Temperature Scale. The Bureau is also responsible for improving the accuracy of this scale; a recent development is a photoelectric pyrometer that eliminates personal error in making the brightness match a part of the pyrometer procedure.

Although the processes taking place, for example, in the combustion chamber of a rocket engine must often be studied under actual operating conditions, the use of such a source of heat for laboratory investigations of fundamental properties of materials is generally ruled out by difficulties in controlling the temperature and in isolating the process studied from the effects of extraneous reactions. Instead, various other types of heat source have been developed—electric arcs, solar furnaces, resistance and induction electric furnaces—each with its particular advantages for special kinds of high-temperature research. Improvements in design or method of use have been made in nearly all of these devices.

Considerable progress has also been made in developing or improving instrumentation for measuring crystallographic, thermodynamic, and chemical properties of materials at elevated temperatures. Included are instruments used in investigations of inversions and phase transitions by differential thermal and thermogravimetric analysis, in X-ray diffraction studies of crystal structure and its changes at high temperatures, in observation of gas-solid reactions by time-lapse photography, and in measurement of liquid viscosity.

Photoelectric Pyrometer

During the past year the high-temperature measurements laboratory constructed a photoelectric pyrometer[1] that is expected to replace the presently used disappearing-filament optical pyrometer for measuring temperatures above 1000°C. The basic optical system and disappearing-filament principle are retained, but the brightness of the test body is compared with that of the pyrometer lamp photoelectrically rather than visually. Early tests of the photoelectric device show a substantial gain in precision.

The instrument consists of a telescope with a 2.5-in. objective lens that is sighted on the test object whose temperature is to be measured. A lamp with a single

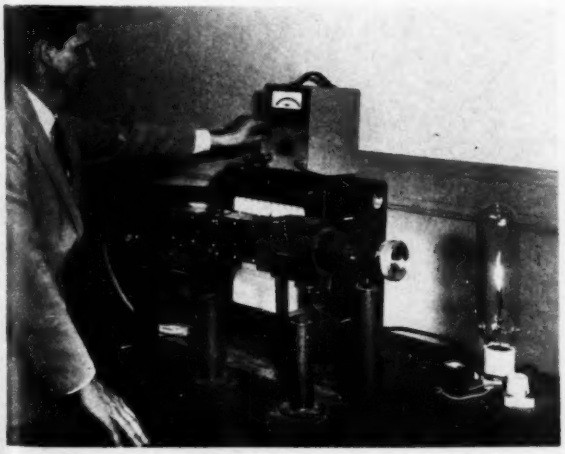
horizontal filament stands inside the telescope on the optic axis, and the image of the test object is focused in the plane of the filament. An eyepiece lens then forms an image of the filament superimposed on the image of the test object. To the eye, the filament can be made to disappear against the background of light from the test object by suitably adjusting the current in the filament. The relation between current, brightness, and temperature of the filament is determined from observations on a black body at the gold point (1063°C) and calculations based on the fundamental laws of radiation.

In order to replace the visual judgment of equality of brightness by a photoelectric determination, a diaphragm with a horizontal slit is set in the image plane of the eyepiece lens and a photomultiplier tube behind the slit measures the intensity of the light passing through. A rectangular block of glass, with optically flat faces and about 1 in. thick, is placed in front of the slit and made to rotate slowly. This causes the image (filament against background of test object) to move past the slit, so that successive portions of the image are scanned by the photomultiplier tube. If there is no variation in brightness as the image is scanned, no change in photomultiplier current is observed.

In this way a precision of 0.1°C is attainable when observing a black body at 1100°C. An interference filter with a bandpass of roughly 50 A (angstroms) can be placed before the slit to make the instrument approximately monochromatic; most tests have been made in this manner, in the vicinity of 6500 A.

The detector is a commercially manufactured experimental photomultiplier tube using the recently discovered multi-alkali metal cathode which has an extremely high quantum efficiency (ranging from 19 per cent at 4200 A to 4 per cent at 6500 A). The cathode consists of a mixture of all five of the alkali metals, and the reason for its unusual effectiveness is not definitely known.

Measuring the temperature of a lamp (right) with the photoelectric pyrometer recently designed and constructed by the National Bureau of Standards for temperatures above 1000°C. Eliminating visual judgments of brightness, instrument shows a substantial gain in precision over currently used disappearing-filament pyrometers. Scientist is adjusting amplifier that feeds output of pyrometer to recording instrument in rear.



Electric Furnaces

Though other methods of generating high temperatures have been developed (solar furnaces, electric arcs, high-velocity gases), the electric furnace—resistance or induction—continues as a major research tool for temperatures as high as 3000°K. In the Bureau's high-temperature program a very large number of electric furnaces are employed. To meet the requirements of advanced research, many of these have been adapted to new experimental techniques and improved designs have been developed that extend the upper limit of temperature attainable or produce more uniform and accurately determined temperatures.

For investigations in air or other oxidizing atmospheres, conventional wire-bound resistance furnaces are restricted to a maximum of 1900°K, the highest temperature at which platinum can be used with any dependability. This upper limit is increased to 2300°K in the thoria (thorium oxide) resistance furnace developed by the Bureau.[2]

In this furnace, the thoria heating elements contain a small amount of cerium oxide to increase their conductance. The conductance is still so low at moderate temperatures that it is necessary to preheat the thoria with auxiliary heaters to 1200°K, at which temperature, however, the resistance is reduced sufficiently for the thoria to carry its own heating current. Because of its large capacity and its applicability to work under oxidizing conditions, the thoria furnace has been particularly useful in determining melting points, coefficients of thermal expansion, and phase equilibrium relationships of refractory materials.

Temperatures above 1900°K are usually obtained with molybdenum, tungsten, tantalum, and graphite heating elements. These substances must be protected against oxidation by a neutral or reducing atmosphere, and this seriously restricts the atmospheric conditions in which investigations can be undertaken. Nevertheless, within these conditions, the Bureau has many induction and

(*Continued on page* 504)

National Bureau of Standards solar furnace converted from U. S. Army surplus searchlight. The furnace can produce temperatures up to 3500°C to melt refractory materials. Flat mirror (heliostat) at left collects light and reflects it into the parabolic mirror at right.

A Drawn Sheet Glass Process of 1871

By EDWARD BOREL, Romont, Switzerland

Translated by S. R. Scholes

Application for patent on the manufacture of window glass by a melting furnace, and by continuous working, that is, by endless glass sheet. Done May 5, 1871, by M. Vallin.

• BELGIUM IS ABOUT to pay homage to two of her sons, Messrs. Fourcault and Gobbe, who are rightly considered the promoters of the mechanical fabrication of window glass by drawing. The Belgian Postal Service has issued a stamp portraying these two great inventors, whose names are known throughout the world of window-glass manufacturing.

It seems equitable to honor here another pathfinder. On May 7, 1871, Monsieur F. Vallin, of Givors, resident of Me Cussac, Rue Neuve, St.-Etienne (Loire), took out a patent which is probably the first patent covering the mechanical drawing of glass.

Let Vallin himself speak through his patent No. 91,787 (France):

"My furnace is heated by ordinary means. The crucibles (pots) which it contains are arranged so as to pass the glass on from one to another. These pots enclose in the thickness of their wall a tube which permits the molten glass coming from the bottom to flow to the surface of the pot. The last pot also encloses a tube within the thickness of its body, but this one is to receive the glass in its upper part and carry it to the bottom.

"This last pot produces sheets of window glass. This pot, which has an oval form, is surmounted by a large pipe which reaches up through the crown of the furnace.

"To commence the work I dip a metallic sheet into the molten glass and give an upward movement to this sheet; the molten glass adheres to the sheet then comes in contact with the metallic guides and there unites. These guides regulate the width of the glass sheet. Their separation and their level can be changed as desired. The sheet of glass which follows the metallic sheet passes between a pair of wind pipes furnished with a series of slits, or a vent, intended to blow air against the glass and downward toward the pot to increase the rate of cooling.

"There are one or two pairs of plates, automatic brakes, designed to retain the glass or its debris in case of accident and to prevent its falling into the pot. I can equally well replace one or the other pair of plates or brakes by a pair of rollers covered with asbestos cloth.

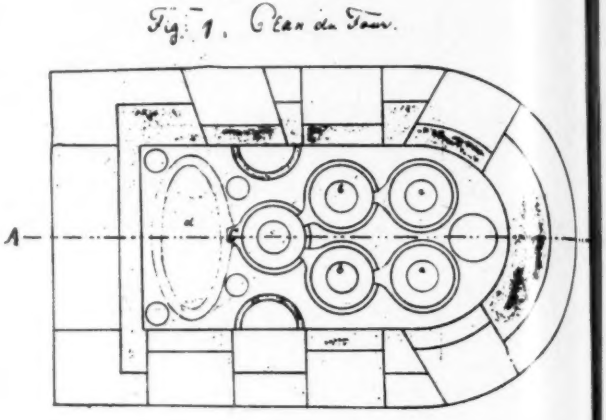
"ii, ii represents a plurality of elevating rolls, the motion of which gives a speed to the glass which is variable according to desire. Above this system of rolls, the sheets of glass are cut off.

"The cylinder *h* is intended, if that is desired, to turn the glass into a horizontal direction toward the driving rolls LLLL. The cylinder *m* serves to bend the glass vertically downward toward the driving rolls nnnn. To cut the horizontal panes, I make them slide over a table covered with asbestos.

"Such is the specification which I announce to the industry and for which I request a patent application of five years."

May 5, 1871. VALLIN

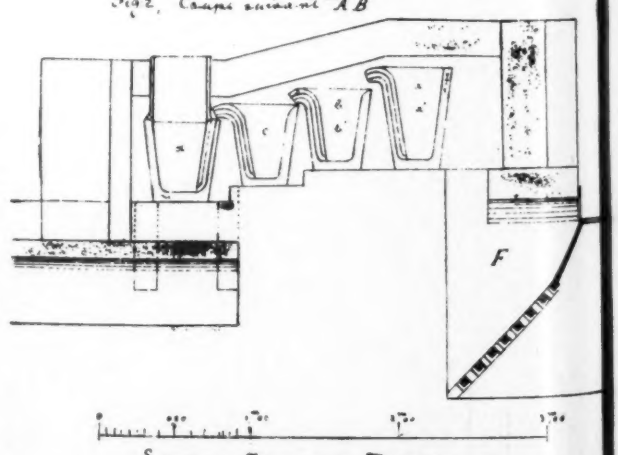
Fig. 1. Plan of Furnace.



Upon reading this patent, one is surprised to find that Vallin, truly a genius, has presented and foreseen all the

(*Continued on page* 509)

Fig. 2. Section through AB.



Scale, 0.04 for Figs. 1 & 2

The original French paper was submitted to *the Glass Industry* by Dr. Alexander Silverman and publication of a translation was authorized by M. Borel in a letter to Dr. Silverman.

(1re application.) Brevet d'invention pour la fabrication de verre à vitre pour un four [illegible] à fusion et travail continu, dit « four Siemens » pris le 9 mai 1871 par F. Vallin.

F. Vallin

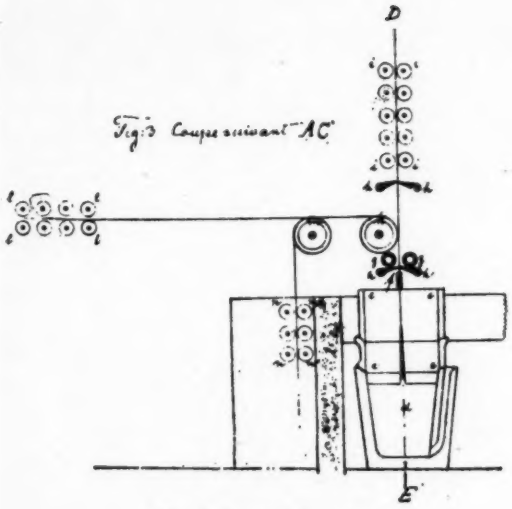


Fig. 3. Section through AC.

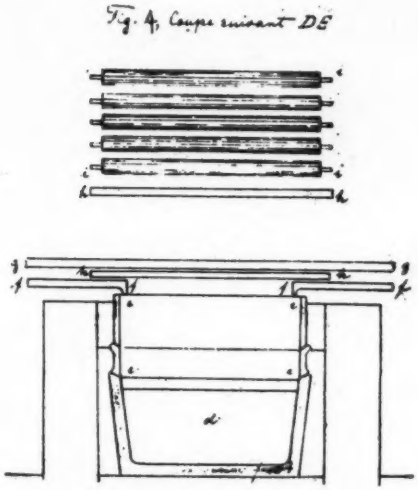


Fig. 4. Section through DE.

Échelle de 0m.05 pour les Fig. 3 et 4.

Scale, 0.05 for Figs. 3 & 4

Legend:

a, a'; b, b'; c; d	Pots or crucibles
F	Fire-box
eeee	Pipe, or chimney, through crown
ff	Metal guides for regulating width of sheets of glass
gg	Wind pipes for cooling the drawn sheet
hhhh	Plates; automatic brakes
iiii	Elevating rollers
k	Cylinder, for bending the sheet into a horizontal direction, if desired, toward the driving rollers cccc
m	Cylinder, for bending the sheet into a vertically descending direction toward the driving rollers nnnn

Légende

a a b b c et d Pots ou creusets.
F Foyer
e e e e Tube reposant sur le sommet de [illegible] et traversant la voûte du four
f f Guides [illegible] pour régler la largeur de la feuille de verre
g g Tuyaux souffleur pour activer le refroidissement de la feuille étirée
h h h h Lames pour arrêts automatiques
i i i i Rouleaux élévateurs
k Cylindre pour plier la feuille en sens horizontal, en cas de besoin, vers les rouleaux moteurs cccc
m Cylindre pour plier la feuille en sens vertical descendant vers les rouleaux moteurs n n n n.

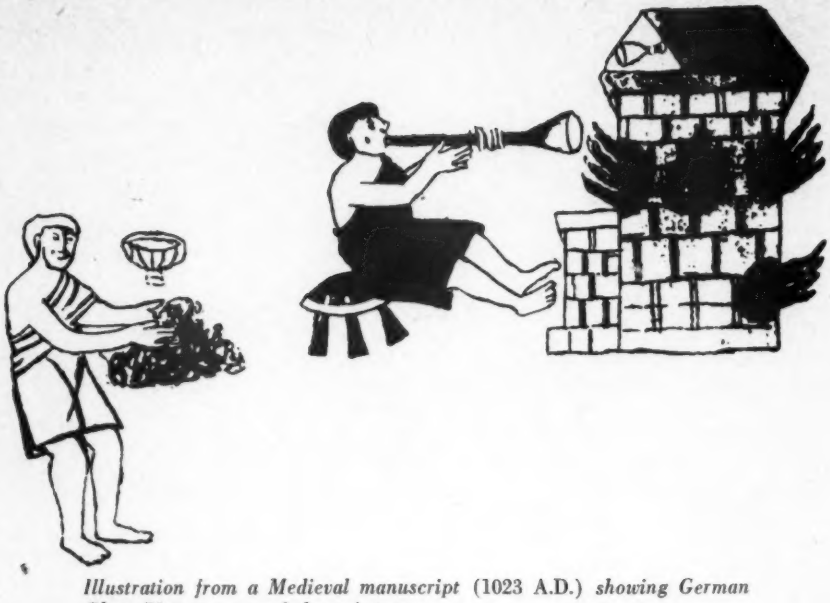


Illustration from a Medieval manuscript (1023 A.D.) *showing German Glass Blowers at work by a furnace.*

Teen Age Glass Blowers in Business

By H. H. SLAWSON, Chicago, Ill.

• AMERICAN TEENS CO., a Chicago firm engaged in glass blowing, was established in 1957 by a group of teenagers. It recently received the much sought-after award, "Best Company in the Area," from Junior Achievement of Chicago. This accolade was won in competition with 322 other companies in Chicago and vicinity.

Junior Achievement of Chicago is a unit of the nationwide organization whose program is designed to help youths gain business experience in organizing and operating businesses of their own.

American Teens Co. was organized in September of last year under the leadership of Jerry Stypa, age 15, president; Charles Skorup, 16, vice president; Joyce Bianchi, 16, secretary; and Gary Judkins, 16, treasurer. Their business, they decided, would be in making Christmas tree ornaments.

But even before they could set up the manufacturing department, problems, which seemed almost insurmountable, kept arising. Their greatest handicap was that no one knew anything about glass blowing, and so it was necessary for them to learn as many of the techniques of this ancient art as possible—a major undertaking that might have discouraged a less ambitious company.

During the first four weeks of manufacture, operations were delayed further by continual breakdowns of the three flame stations—crossfire burners with five gas jets.

The next great hurdle was that of procuring raw materials. There was only one company in the United States, they finally learned, which could supply them with the glass icicles (copper wire with nickel core) needed for making the tree ornaments.

This supplier, a subsidiary of Westinghouse, was quite familiar with the national Junior Achievement program, and when contacted by American Teens, an executive of the firm had the necessary stock shipped immediately to the young company. From that moment the business gained momentum.

American Teens opened a "factory" in the space reserved for them, along with other companies, at the South District Junior Achievement business center at 3241 West 63rd Street, Chicago, and began building up an inventory of Christmas tree decorations in anticipation of the approaching holidays.

The sales department held frequent conferences to study the market potential in the Chicago area, concluding that the most effective approach would be a dynamic door-to-door selling drive among their neighbors.

As a result of their energetic campaign, sales doubled, and they trebled. Demand was so great that the production crew was frequently forced to work overtime.

Each Junior Achievement firm always has a sponsor whose purpose is to provide advice on financial matters, and on production and sales procedures. American Teens was guided by the Chicago branch plant of Rheem Mfg. Co. Advisors were Al Rogers, Ed Wucka, Jim Curfman and Chris Altier.

Mr. Altier, in his own capacity, handles the glass blowing requirements for Rheem products, and so it was natural that he be chosen technical advisor to American Teens. He has been close to glass blowing since 1915 when, as a boy of 10, he came to the United States and delved into the art as a hobby. His Viennese family be-

(*Continued on page* 510)

BELKNAP APPOINTED BY CORNING

William J. Belknap has been appointed director of government services for Corning Glass Works and will be responsible for the coordination and exchange of information between governmental agencies and the divisions of Corning Glass Works.

William J. Belknap

He joined Corning in 1941 as manager of priorities, later serving, in turn, as manager of market research, manager of lighting sales, manager of advertising and sales promotion, assistant to the president, and manager of administration in the research and development division. Most recently he has been in charge of capital planning and control in the controller's division.

CERAMIC-IN-GLASS ELECTRON TUBE

Sylvania Electronic Tubes, a division of Sylvania Electric Products Inc., has developed a "ceramic-in-glass" electron tube by adapting the principles of the ceramic "packed" tube, introduced by the company in 1954, for use in the conventional glass envelope, or bulb. This "glass" tube, according to Matthew D. Burns, division president, is capable of withstanding extreme conditions of vibration, shock and fatigue.

The new electronic device is expected to lead to improved performance of many types of electronic equipment, including guided missiles and satellites.

PORTER PLANT NEARING COMPLETION

The new refractories plant of H. K. Porter Company in Pascagoula, Miss., is more than 75 per cent completed and is expected to be ready for production late this year. Said to be one of the most modern refractory brick-making operations in the country, the multi-million dollar structure will use magnesia obtained from sea water for the production of chrome-magnesite, magnesite-chrome and periclase-type basic brick in burned, unburned and steel-encased bodies.

The new plant will serve the glass field, among other major industries, in the manufacture of products for glass tank checkers, regenerator walls, and other structures.

The seven tanks for producing the magnesium hydroxide from sea water vary in size from 60 to 300 feet in diameter, the smallest tank being for sea water treatment, and the largest, for thickening magnesium hydroxide precipitate.

The most modern methods will be used in grinding, batching and pressing brick, and controlled sized fractions will be stored in 60 bins which will supply both the brick-making and specialty operations. Batching operations will be highly automated, controlled by one man for the entire plant. All electrical and electronic controls for the batching system will be housed and operated from a central, air-conditioned room.

FRANKLIN INSTITUTE MEDALS

The Walton Clark Medal of the Franklin Institute will be presented to Frederic O. Hess, president, Selas Corporation of America, on October 15 at formal ceremonies in Franklin Memorial Hall of the Institute. The award will honor Mr. Hess' development of new processes for the industrial use of gas.

Frederic O. Hess

Mr. Hess is the author of 55 papers and articles and is credited with achieving closer control over the temperatures of natural gas by his development of burners made of exceptionally high heat-resistant refractory material. He has had 58 patents issued to him individually and 25 patents as a joint inventor.

James Bailey, consulting engineer for Plax Corp., and Dr. George S. Crampton, Professor Emeritus of Ophthalmology at the University of Pennsylvania Medical School, will receive the Edward Longstreth Medal, also on October 15.

The citation to Mr. Bailey reads, "For the many advances in the art of processing plastics based on his personal technical contributions and his effective leadership in research and development, and particularly of the development under his direction of methods for the successful commercial manufacture of unbreakable plastic bottles."

Mr. Bailey has been issued 45 patents in the plastics and glass fields and has written 21 articles on the subjects. In 1937 he joined the staff of the Hartford Empire Co. which subsequently named him vice president and director of research of Plax Corporation.

Dr. Crampton is being honored for "His development of the Borescope, a specialized periscope for the internal inspection of turbine shafts, rotors, guns and various closed vessels, by which flaws may be detected, thereby providing protection of vital importance from the physical and economic hazards of operational failure."

TO SPEED AUTO GLASS REPLACEMENT

The recently completed warehouse at the East Toledo plant of Libbey-Owens-Ford Glass Company will provide greater flexibility and speed in handling shipments of automotive replacement safety glass. It has approximately 100 storage bays, each 40 feet square, which will be used for rapid selection of various parts carried in the inventory, while a depressed railroad connection, with space for six boxcars, and docks for six motor trucks will expedite shipment in and out of the warehouse.

To speed up the packaging operations, cartonizing equipment has been moved into the new warehouse so that jobbers may be served with either the conventional production packs of 20, 25 or 30 windshields, or smaller packs of eight windshields, or the individual windshield parts cartons. Block sizes of flat safety plate and safety sheet glass will also be cartonized in packs of six lights each for shipment to jobbers.

Inventions and Inventors

Annealing and Tempering

Method and apparatus for coating glassware. Patent No. 2,813,045. Filed February 23, 1955. Issued November 12, 1957. One sheet of drawings; none reproduced. Assigned to Owens-Illinois Glass Company by Raymond B. Abbot, Jr.

The present invention is a novel and economical method of an apparatus for applying a lubricous protective coating or film to the exterior surfaces of glass containers, such as bottles and jars.

It has been ascertained, for example, that polyoxyethylene stearate (a water-soluble wax) produces an excellent lubricous film on glass surfaces if applied under properly controlled conditions, as regards temperature and surrounding atmosphere.

Glass bottles, jars, or similar container, while in normal upright position, and out of physical contact with one another, are carried through the annealing lehr. The temperature conditions are so regulated that when the containers reach the coating zone their exterior surfaces, at least, are within a temperature range of about 140° to 200°F. In this zone the containers travel slowly through an upward moving vapor cloud which is the product of a dilute aqueous solution composed of water and about 0.025 per cent polyoxyethylene stearate (water-soluble wax) or some other suitable organic material having similar lubricating characteristics.

The dilute aqueous solution of lubricous organic material is delivered at about 80°F, and approximately 5 p.s.i., to the vaporizer. This vaporizer is a flash type steam generator designed to produce low pressure superheated steam. The exceedingly rapid vaporization of the water in the solution develops sufficient kinetic energy at the elevated temperature (about 600°F) to transform the lubricous materials into a vapor. Thus, fractional distillation does not occur, and the original solution is discharged from the vaporizer in a dry vapor phase.

Following the coating step, the containers move on until they are beneath a cooling fan. Here the containers and the coating material are cooled rather rapidly, resulting in the desired setting of the coating.

There were 2 claims and the following references cited in this patent.

United States Patents

2,016,381, McBurney, Oct. 8, 1935; 2,355,225, MacWilliam, Aug. 8, 1944; 2,369,737, Jackson et al., Feb. 20, 1945; 2,511,797, Hochberg, June 13, 1950; 2,539,159, Peiler, Jan. 23, 1951.

Foreign Patents

417,102, Great Britain, Sept. 27, 1934.

Feeding and Forming

Continuous glass molding machine. Patent No. 2,811,815. Filed February 11, 1954. Issued November 5, 1957. Sixteen sheets of drawings; none reproduced. No assignee. John W. Eldred.

The present invention relates to molding machines, having particular reference to an improved continuously operating machine formed to utilize a constantly rotating mold structure, by which a high productive output is provided for forming molding articles of various kinds from glass and other moldable materials.

The object of the invention is to provide a continuous molding machine employing a rotary mold-supporting table on which is carried a plurality of circumferentially spaced mold assemblies. An improved mechanism is provided for feeding gobs or gathers of molten glass or the like to each mold assembly. The mechanism is so constructed as to deliver successively the heated moldable material to the internal cavities of such assemblies while the rotary motion of the table is maintained. During each complete cycle of rotation of the table each of said mold assemblies deposit material and is shaped into article formation.

There were 12 claims and 11 references cited in this patent.

Furnaces

Apparatus for Supplying Batch Materials to a Glass Furnace. Patent No. 2,804,981. Filed October 24, 1952. Issued September 3, 1957. No drawings. Assigned to Libbey-Owens-Ford Glass Company by James F. La Plante and Delmar E. Carney.

The present invention relates broadly to the supplying of batch materials to melting tanks. More particularly, it has to do with an improved apparatus for attaining a more rapid and thorough melt of glass at a constant level by introducing the batch materials across the surface of the molten glass in the glass tank-furnace into predetermined locations in a definite sequence and at regularly spaced intervals.

Batch materials are supplied to a tank-furnace in relatively small quantities and then distributed over a large surface area of the molten glass contained in such a furnace without causing surging action of the already molten glass.

A control means is provided whereby an apparatus will be caused to move discharged glass batch materials into a tank-furnace, direct the batch materials laterally into the body of molten glass therein and distribute such batch materials into areas of the molten glass in alternating sequences toward one side and then the other side of the tank-furnace. The apparatus is of particular value in the continuous production of sheet or plate glass.

There were 12 claims cited in this patent.

Glass Compositions

Method for bending and tempering glass. Patent No. 2,805,520. Filed June 10, 1952. Issued September 10, 1957. Three sheets of drawings; none reproduced. Assigned to Pittsburgh Plate Glass Company by Lloyd V. Black.

(*Continued on page* 512)

Selenium Utilization in Soda-Lime-Silica Glass Manufacture

• DIFFICULTIES IN THE SUPPLY of selenium have caused two major crises in the container-glass industry within the last seven years. Selenium, along with cobalt, is universally used to decolorize the soda-lime-silica glass produced in tank furnaces. The shortage which developed in selenium during 1951 and 1955-56 meant that manufacturers had to examine most critically all possible means of economizing in its use. Without such economies it was inevitable that a proportion of the output would have to be made without decolorizing; the bluish or greenish appearance of such glass is less attractive and less acceptable for many purposes. Apart from the difficulty in obtaining sufficient selenium, a further factor of great commercial importance was its cost.

The glass industry undertook, therefore, a detailed study of the use of selenium, and it also supported investigations into the possibility of using other materials as substitutes.

Dr. D. K. Hill in the February, 1958, issue of the *Journal of the Society of Glass Technology* records the recommendations made by firms in the glass industry at the time of the earlier crises.

From data supported by a number of manufacturers, it is clear that excessive use of arsenic entails the use of unnecessarily large amounts of selenium, and this factor was proved to be the outstanding method of reducing selenium consumption. With no arsenic, however, the tint of the glass is much more susceptible to changes in a variety of operational conditions. For example, the glass color is more sensitive to changes in load, to changes in the iron content, and to changes in combustion conditions, but (perhaps not unexpectedly) less sensitive to heat treatment.

The stabilizing influence of arsenic on the color presumably depends on maintaining a fairly consistent level of oxidation within the melt. It is known that if sodium nitrate is present the amount of arsenic can be reduced and, in turn, so can the selenium, but it appears that neither nitre nor any other oxidizing material is capable of fulfilling all the functions of the arsenic. Thus it is necessary to compromise between color stability and minimal use of selenium. In practice most manufacturers adjusted the arsenic content until they achieved a color which was reasonably stable under their particular operating conditions.

The effect of nitre has been briefly referred to above in connection with arsenic. The functions of the nitre appear to be:

(a) to provide oxygen for the melt, and (with arsenic) to promote oxidation of the iron present.

(b) to provide a low-melting-temperature flux, and

(c) to burn off any 'dirt' in the batch.

If selenium is reduced in amount as a result of using arsenic plus nitre in place of arsenic alone the question of relative costs of the batch before and after the change needs consideration. It has been stated (F. W. Hodkin, 1952) that arsenic/nitre glasses may have a faint residual yellowish tint—not sufficient to invalidate their commercial acceptability—by comparison with the arsenic-only glasses. In spite of this comment most manufacturers regard the use of nitre as being worth-while and having beneficial effects on both melting rate, color and selenium requirements.

It was generally agreed that increased use of sulphate necessitated increased amounts of selenium; the selenium requirement was not, however, by any means as sensitive to changes in sulphate as in arsenic. No evidence was available to suggest that any other sulphate was better, or worse, than salt cake in this respect but it was commented that as salt cake was increased there might be a tendency to develop a yellowish tint in the glass which could not be eliminated by normal decolorizing procedures.

No positive evidence on the influence of fluorine was available, although a number of manufacturers felt sure that the inclusion of the normal small amounts of fluoride in container batches had no adverse effects on selenium requirements. It was, in fact, considered that the inclusion of, say, 2-4 lbs. calcium fluoride per 2000 lb. batch materials might enable a slight reduction to be made in the selenium.

It was suggested that reductions in the amount of selenium required might be achieved if sodium chloride were used in place of an equivalent amount of soda ash or salt cake. The amount of sodium chloride suggested was of the order of not more than 4-6 lbs. per 2000 lb. of batch. Again, no figures were available on which this proposal could be judged.

The use of small amounts of borax was mentioned as giving a further possibility of achieving some small reduction in the amount of selenium. Again this could not be confirmed from the information available, and one manufacturer denied that any advantageous effects could be attributed to borax in this connection.

When cullet is brought into a glassworks it usually contains a great deal of organic matter—cork, wood, packaging materials, general "dirt", etc., and aluminum, all of which exert a reducing action in the furnace. It is generally agreed that for satisfactory decolorizing the iron in the glass should be as far as possible in its higher state of oxidation, and the presence of contamination means, therefore, that extra quantities of arsenic, nitre, or both must be present to provide oxygen for burning it away. If to do this involves an increase in arsenic then, extra selenium has to be used.

The moral here is clear: both for low pick-up of iron and for good decolorizing the cullet must be as clean as possible, and contamination of any kind should be removed. Hand-picking may be well worth-while.

Only one set of data gives a quantitative estimation of the benefits of using cleaner cullet. The introduction of

a washing plant and removal of aluminum bottle caps was largely responsible for halving the selenium requirement in that works.

The purpose of decolorizing is to eliminate the colors due to iron, and it is clear that the use of raw materials with lower iron content should have a beneficial effect on the amount of selenium required. It seems, however, from the evidence made available, that the selenium requirement is not directly proportional to the amount of iron, and that for relatively low iron content rather more selenium may be required per unit quantity of iron than at higher concentrations. Nevertheless, so far as practical glassmaking is concerned it is true to say that the lower the iron content the smaller the amount of selenium needed, and any possible sources of contamination should be eliminated. Satisfactory decolorizing appears almost impossible to achieve by existing techniques if more than about 0.08 per cent Fe_2O_3 is present in the glass.

Although it appears that arsenic helps to maintain a consistent color in the furnace there is considerable evidence that the tendency for glassware to develop a pinkish or brownish tint in the lehr may be directly associated with the need to use more selenium when arsenic is present. The phenomenon of 'pinking' is usually associated with either a hot lehr, a thick-sectioned article, or some other condition which would give rise to a relatively slow cooling of the glass through the annealing range. It is, for example, quite common to find a greenish color when looking down the mouth of a bottle, whereas the color through the base may be pinkish to pale brown. This effect may be explained by the fact that during forming, the neck region is chilled relatively rapidly compared with the rest of the bottle and little opportunity is afforded for the development of selenium color.

As the amount of selenium in the glass is decreased the 'pinking' effect becomes less pronounced. Conversely, for a given amount of selenium in the glass, the best development of the pink color occurs when the lehr is run as hot as possible without running the risk of ware distortion: glasses which would appear greenish if cooled too abruptly in the lehr may, as a result of the higher temperature treatment, become of acceptable color. Hence the same decolorizing effect can be obtained by less selenium if lehr temperatures are suitably adjusted. The problem remains, however, of decolorizing articles of widely different sizes, made at the same time from the same furnace. To avoid undesirable differences in shade between large and small articles the only really satisfactory approach seems to be by reducing the total amount of selenium in the glass.

Although strongly adverse conditions such as smoky flames licking the glass surface or oil droplets falling on the glass will produce local strongly reducing conditions which may seriously affect the glass color, it is probably correct to suggest that the glass color is less sensitive to changes in the atmosphere above it than it is to changes in the "internal oxygen pressure" created by arsenic, nitre, and other batch materials. For optimum conditions it seems that a slightly oxidizing atmosphere, i.e. a little excess air, is desirable, but apart from this general condition it is probable that the atmosphere is not very critical. It would in any case be poor practice to run a furnace with strongly reducing conditions, which implies almost inevitably inefficient combustion and smoke. The consensus was that the optimum arsenic and nitre levels would undoubtedly differ a little between furnaces depending on the design, condition, and operation of the unit, in addition to variations attributable to other factors.

A factor which may be of significance is the heat-transfer pattern of the furnace. If the combustion conditions and batch-charging arrangements are such that the raw materials are melted down and enveloped in glass as quickly as possible then there will be less opportunity for selenium to volatilize away. It would seem possible that the benefits claimed for fluoride, chloride and borax (for example) might, if confirmed, be related to the ease of melting of these materials.

There was some evidence that the amount of selenium required for a given glass was affected by the "load" on the furnace. In one case it had been found that if the load increased, smaller proportions of selenium were needed. The effect is presumably due to the shorter sojourn of the glass in the furnace giving less time for refractory solution and selenium volatilization. This finding was not confirmed, however, in another case where arsenic had been completely eliminated from the batch.

Practically all manufacturers had considered the possibility that various selenites or selenates might offer advantages over elementary selenium, but they had not found it worth-while to use the selenium in a chemically combined form.

Based on the considerations indicated above, a letter was sent to members of the industry suggesting that, for a glass with about 0.07 per cent Fe_2O_3, reasonably good practice could be represented as follows:

arsenic	1 lb.	per 2000-lb. batch
sodium nitrate	3 lbs.	per 2000-lb. batch
selenium	½ oz.	per 2000-lb. batch

It was appreciated that some firms were already achieving satisfactory results with amounts less than those quoted, which could in any case only give a general indication of practicable levels.

HARTFORD-EMPIRE BRANCH OFFICE

The Hartford-Empire glass container machinery division of Emhart Manufacturing Company opened a new branch office last month at 2677½ East Main Street in Columbus, Ohio. James E. Harrington is manager, and Kenneth J. Leavell, assistant manager.

GRIEM APPOINTED BY HUNT FOODS

Paul Griem has been appointed manager of the new glass division of Hunt Foods and Industries, Inc. He had previously been in charge of glass manufacturing operations. In his new post Mr. Griem will be responsible for the glass operations of the company, including its subsidiaries, Glass Containers Corporation and United Can & Glass Company.

Edward Goldstein, formerly a member of the legal staff, has become assistant manager of the glass division.

Current Statistical Position of Glass

Employment and payrolls: Employment in the glass industry during June, 1958, was as follows: *Flat Glass:* a preliminary figure of 24,500 given for June, 1958, indicates an increase of 9.4 per cent over the adjusted 22,400 reported for May, 1958. *Glass and Glassware, Pressed and Blown:* an increase of 2.8 per cent is shown by the preliminary figure of 80,600 reported for June, 1958, when compared with the adjusted figure of 78,400 recorded for May, 1958. *Glass Products Made of Purchased Glass:* the preliminary figure of 12,500 given for June, 1958, indicates an increase of 2.5 per cent over the previous month's adjusted figure of 12,200.

Payrolls in the glass industry during June, 1958, were as follows: *Flat Glass:* an increase of 8.4 per cent is shown in the preliminary $11,055,346.19 given for June, 1958, when compared with May's adjusted $10,199,-951.33. *Glass and Glassware, Pressed and Blown:* an increase of 2.5 per cent is shown in the preliminary $29,-947,312.85 reported for June, 1958, when compared with the previous month's adjusted $28,776,596.91. *Glass Products Made of Purchased Glass:* a preliminary figure of $3,816,831.38 was reported for June, 1958. This is an increase of 4.7 per cent when compared with the adjusted figure of $3,646,990.77 for May, 1958.

Glass container production: production based on figures released by the Bureau of the Census, Industry Division, was 12,716,000 gross during July, 1958. This is a decrease of 0.04 per cent from the previous month's production figure, 12,721,000 gross. During July, 1957, glass container production was 12,622,000 gross, or 0.7 per cent below the July, 1958, figure. At the end of the first seven months of 1958, glass container manufacturers have produced a preliminary total of 83,626,000 gross. This is 2.2 per cent below the 85,504,000 gross produced during the same period in 1957.

Shipments of glass containers during July, 1958, came to 12,300,000 gross, a decrease of 0.6 per cent from June, 1958, shipments which totaled 12,376,000 gross. Shipments during July, 1957, amounted to 12,503,000 gross, or 1.7 per cent above July, 1958. At the end of the first seven months of 1958, shipments have reached a preliminary total of 81,227,000 gross, which is 0.6 per cent over the 80,716,000 gross shipped during the same period of the previous year.

Stocks on hand at the end of July, 1958, came to 19,512,000 gross. This is 1.9 per cent above the 19,145,-000 gross on hand at the end of June, 1958 and 7.2 per cent higher than the 18,204,000 gross on hand at the end of July, 1957.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers

	July, 1958
Food	1,210,000
Medicinal and Health Supplies	1,132,000
Chemical, Household and Industrial	823,000
Toiletries and Cosmetics	862,000
Beverage, Returnable	785,000
Beverage, Non-Returnable	151,000
Beer, Returnable	275,000
Beer, Non-Returnable	985,000
Liquor	681,000
Wine	306,000
Sub-total (Narrow)	7,210,000

Wide Mouth Containers

Food	*3,882,000
Medicinal and Health Supplies	335,000
Chemical, Household and Industrial	173,000
Toiletries and Cosmetics	239,000
Packers' Tumblers	49,000
Dairy Products	136,000
Sub total (Wide)	4,814,000
Total Domestic	12,024,000
Export Shipments	276,000
TOTAL SHIPMENTS	12,300,000

*This figure includes Fruit Jars and Jelly Glasses.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production July, 1958	Stocks July, 1958
Food, Medicinal and Health Supplies; Chemical, Household and Industrial; Toiletries and Cosmetics	Narrow Neck	4,490,000	7,486,000
	Wide Mouth	*4,763,000	*6,296,000
Beverage, Returnable		713,000	1,875,000
Beverage, Non-Returnable		123,000	271,000
Beer, Returnable		302,000	372,000
Beer, Non-Returnable		978,000	731,000
Liquor		826,000	1,366,000
Wine		350,000	683,000
Packers' Tumblers		43,000	125,000
Dairy Products		128,000	307,000
TOTAL		*12,716,000	*19,512,000

*This figure includes Fruit Jars and Jelly Glasses.

New Plant for Mexico Refractories

Mexico Refractories Company was authorized on August 16 by the board of directors to build a $2 million refractories plant near Stockton, Calif. The board also announced that a million-dollar modernization of its Mexico, Missouri, plant would be completed by the end of this year.

The Stockton unit will be the sixth manufacturing plant in the Mexico Refractories Company system for the manufacture of fireclay and silica brick and refractory mortars, plastic firebrick and insulating materials.

John W. Mantz

William H. McConnell

Henry B. Clark

Samuel S. Savage

DIAMOND ALKALI APPOINTMENTS

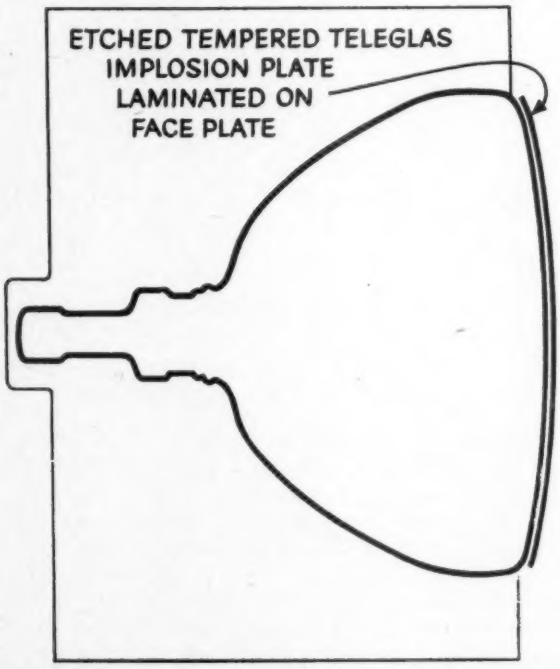
Diamond Alkali Company has promoted four key executives to positions of broader management responsibility as a part of a long-range, company-wide program.

William H. McConnell, vice president of sales since 1953, has become vice president of marketing. He will be primarily concerned with the expanding requirements of the company's marketing and sales management.

Henry B. Clark, general manager of Diamond's soda products division for the past 2½ years, is now director of sales, a newly created post. He will take over some of Mr. McConnell's former duties and will be responsible for the management of the company's nine branch sales offices and the administration of its market planning program.

John W. Mantz, general manager of the silicate, detergent, calcium division since its formation in June, 1954, is now general manager of the soda products division.

Samuel S. Savage has become general manager of the international division which has just been established to meet the increased needs of the company's foreign sales and manufacturing interests. He had formerly been director of export sales, active in both domestic and export chemical sales work.



Sketch of new type television tube developed by Pittsburgh Plate Glass Company. Window is curved to fit tube face.

NAMED PROFESSOR BY CARNEGIE INST.

Leland Hazard, vice president and general counsel of the Pittsburgh Plate Glass Company, has been appointed Professor of Industrial Administration and Law in the Graduate School of Industrial Administration at Carnegie Institute of Technology, effective February 1, 1959.

He will continue as a member of the board of directors of the company, becoming a consultant on legal and other matters; however, on January 1 he will relinquish his duties as vice president and general counsel.

Joseph T. Owens, associate general counsel, will become general counsel on January 1, succeeding Mr. Hazard.

PITTSBURGH PLATE DEVELOPS NEW TV TUBE

Pittsburgh Plate Glass Company has developed a new type of television tube by laminating glass and plastic which, the company states, adds brightness and clarity to the TV reception, and makes it possible to eliminate the separate front window, now standard on all television sets.

Instead of the present outside safety glass window, the new tube will have a lightweight safety glass window curved to fit the tube face and laminated directly to it by means of a layer of Selectron polyester resin.

Advantages, the company states, are greater safety for the television viewer; no objectionable reflections and extraneous room light from the picture tube face; an eight to nine per cent increase in brightness (without the present front window, two reflecting surfaces are eliminated); and no glass-cleaning problem, since there will be only one glass surface instead of the present three.

Several major manufacturers are studying the feasibility of producing the new unit tube and are engineering for pilot plant production.

New Equipment and Supplies

WALSH FC-101 FUSION CAST REFRACTORY

The properties of the Walsh Refractories Corporation new FC-101 fusion cast refractory will represent a decided improvement in the zirconia alumina crystal structure, resulting in greater homogeneity. In the special Walsh process, according to J. J. Duggan, vice president, glass refractories division, the glassy phase is precisely controlled through the addition of special ingredients introduced during the fusion process.

FC-101 will afford longer refractory life and lower cost per ton of glass melted, states Mr. Duggan, because of its greater purity attained through the reduction of oxides, as well as its higher degree of resistance to thermal shock and superior surface texture. The new refractory will have qualities heretofore considered outside the capabilities of ordinary glass refractories.

Walsh Refractories Corporation expects to have its new plant—for the manufacture of FC-101—in full operation by the spring of 1959. The company invites inquiries about this forthcoming fusion cast refractory and will supply chemical analysis and other data in answer to requests directed to the Glass Refractories Division, 101 Ferry St., St. Louis 7, Mo.

VIBRATORY FEEDER

Eriez Manufacturing Company, Erie 6, Penna., has added a new vibratory feeder with a capacity rated at 10 tons per hour to its line of Hi-Vi feeders. This unit is designed to handle medium-to-heavy feeding to batch-weighing scale hoppers, pulverizers, driers, and furnaces where accurate control is essential.

CONTROL DEVICE

Baker Perkins Inc., Saginaw, Mich., has designed a new fast-acting electrical control device which makes it possible to stop an over-loaded electrical motor during the critical peak or starting load period. The device may be installed in conjunction with almost all types of motorized applications.

BATCHING SCALE

Thayer Scale Corp., Pembroke, Mass., has developed a "Low-A-Trol" constant-feed batching scale, utilizing an electronic, closed-circuit control. Final accuracies of 0.1 per cent are claimed for wet or dry materials being fed at rates of from 5 lbs. to 5 tons per hour.

ELECTRONIC COUNTER

Standard Instrument Corporation, 657 Broadway, New York 12, has a new predetermining electronic counter which automatically controls any industrial process involving high-speed counting.

OIL-GAS BURNER

E. W. Bliss Company, Canton, Ohio, announces the Radiant Pulsation-type oil-gas burner which produces a luminous flame with a peak temperature of 3450°F when burning oil, and above 3300°F with 1000 BTU/cubic foot natural gas. Burners are available for heat release rate ranging up to 70,000,000 BTU's per hour.

METALLIZED GLASS FIBER

The Commonwealth Engineering Company, Dayton, Ohio has announced a new patented production process for making metallized glass fiber. The product is so light, the company states, that it floats in ordinary air currents, yet so tough that when formed into thin mats, the metallized glass fiber can resist a projectile's impact or meet the requirements of a building material.

The glass fiber produced with this special plating and bonding process is electrically conductive. Possible uses range from a missile radar decoy material to a decorative element for home and office construction.

The company states that the process is based on a special gas-plating arrangement in which nickel, chromium, copper or other desired metals are applied to the glass fiber in a continuous operation. The process is being made available for license.

VALVE OPERATED CYLINDERS

Airmatic Valve, Inc., 7313 Associate Ave., Cleveland 9, Ohio, has a new line of valve operated cylinders which combines a conventional single-acting cylinder with the new Airmatic 33800 series, 3-way solenoid valve. This is an integral power unit, complete in itself. The valve and cylinder combinations will withstand a minimum of 20 million cycles of operation without a breakdown.

DIAMOND BITS

Hoffman Bros. Drilling Co. is producing a complete line of thin-wall diamond bits for use on such materials as glass, ceramics and granite. These precision tools are adaptable to production line or mobile drill operations.

INSULFLUX

A new product of Walsh Glass Refractories division, Insulflux is said to cut fuel costs because of its excellent insulating properties. The product has a low K factor (below 5), a greater cold crushing strength and a higher modulus of rupture, according to the company, than any other product with a comparable K factor. In the event of tank block failure, the product forms a safety barrier, successfully resisting the escape of molten glass, should this occur.

Insulflux is accurate in size and shape, long-lasting, and can be used again. It is applied, like overcoat blocks, to within 12 inches of the top sidewall blocks of the glass furnace and to within four inches of the bottom and sidewall blocks.

In tanks melting flint glass, vertical joints in sidewall blocks are not covered; however, in tanks making amber or emerald glass vertical joints may be covered.

BELT CONVEYOR SCALE

Weighing & Control Components, Inc., Hatboro, Penna., has developed a unitized, pneumatic, belt conveyor scale which is easily installed on

existing flat-belt or trough-type conveyors with a minimum of downtime and only slight modification to the conveyor. It can be adapted to either fixed or variable speed conveyors.

CATALOGS RECEIVED

Leeds & Northrup Company, 4934 Stenton Ave., Philadelphia 44, Penna., has published a 36-page Catalog (EN-S4) which describes how its Thermohm detectors for temperatures up to 1000°F are being used for many applications in glass, ceramics, chemicals and other fields. A special section includes information of precision resistance thermometers for precise laboratory work involving temperatures from —261°C (12K) to 400°C.

Reliance Electric and Engineering Company, 24701 Euclid Ave., Cleveland 17, Ohio, is distributing a 16-page, full-color booklet (Bulletin D-2506) on Reliance V*S Drives which provide precise, adjustable machine speeds from in-plant a-c circuits.

The Swartwout Company, 18511 Euclid Ave., Cleveland 12, Ohio, has folders available describing its new "Pyrojector", an automatic heat, smoke and explosion relief unit. The Pyrojector opens automatically when fire or explosion strikes, venting smoke, heat, and explosive forces up through the roof instead of spreading them out across a building.

Illinois Testing Laboratories, Inc., 420 North LaSalle St., Chicago 10, Ill., has published a new bulletin (No. 2002) concerning the Alnor Pyrotac. This instrument is primarily an excess temperature protective device which sounds an alarm upon reaching the safe maximum temperature. The bulletin provides complete specifications, schematic application, and wiring diagrams, explaining the principle.

Link-Belt Comapny, Prudential Plaza, Chicago 1, Illinois, has a 154-page book (No. 2657) on precision steel roller chains and sprockets. Written to serve as a practical textbook on the use of roller chain for both power transmission and conveyor service, the book contains typical installation conditions, formulas, charts and diagrams to simplify selection of proper chains for any application.

Diacraft, Inc., 26538 West Seven Mile Road, Detroit, Michigan, describes its new metallic and resinoid bonded Diacraft diamond grinding wheels in a 28-page catalogue. They are made in all customary shapes and sizes for carbide grinding, as well as in custom-made sizes for special applications.

SOVIET RESEARCH ON GLASS

Consultants Bureau, Inc., New York City, is this month publishing complete English translations of 75 papers directly concerned with Soviet research on the structure of glass.

They were originally read at a conference of the Institute of Silicate Chemistry of the Academy of Sciences, USSR, and other affiliated organizations and released in the Soviet Union late in 1957.

Entitled, "The Structure of Glass," these papers present existing theories and recent practical developments in the field by leading Soviet authorities. Among the subjects covered are the use of spectroscopic methods; effects of temperature on the refractive index and coefficient of expansion; and the application of x-ray, electron and neutron diffraction methods.

This work will be available in complete English translation case bound, at $20.00.

FOX APPOINTED BY L.O.F.

Herbert A. Fox, formerly eastern division chief engineer for L.O.F. Glass Fibers Company, has been appointed to the newly created post of director of licensing, with headquarters in the company's general offices, Toledo, Ohio. He will be responsible for all matters pertaining to patents and trade marks, and the licensing of patented processes, for glass fiber products.

ROSE REPRESENTS FMC IN EUROPE

William B. Rose, formerly director of research and development for the Westvaco Chlor-Alkali division, has been named European technical representative for the chemical divisions of Food Machinery and Chemical Corporation in Geneva, Switzerland. He replaces Dr. Charles P. Roberts, in the post three years, who has been transferred to the company's chemical divisions headquarters in New York.

FOREIGN TECHNICAL INFORMATION CENTER

The U. S. Department of Commerce, Washington 25, D. C., has set up a Foreign Technical Information Center whose purpose is to provide American science and industry with access to translations of a large amount of Soviet technical information. The Center is a part of the Office of Technical Services, Business and Defense Services Administration, with John C. Green as OTS Director.

Secretary of Commerce Sinclair Weeks last month announced that the new program would add substantially to the wealth of technical information that OTS can supply to industry in any field.

The work of the Foreign Technical Information Center includes the publication in abstract form of all articles appearing in 141 Soviet technical journals. Abstracts of each issue of the 141 journals may be purchased from OTS on a subscription or single-issue basis.

OTS will soon begin distributing complete translations of articles and books, said Director Green, stating that these translations will be listed in an abstract journal which is expected to begin publication this month, or shortly thereafter.

U. S. BORAX APPOINTMENTS

J. D. Stern has been appointed assistant to the vice president (J. F. Corkill) of the Pacific Coast Borax Company division of United States Borax & Chemical Corp. His new responsibilities will be in the general administrative and executive areas. Mr. Stern had formerly been assistant to the general manager.

P. J. O'Brien has been appointed vice president of production and engineering, and R. F. Steel, vice president of finance and administration of the United States Borax Company. Mr. O'Brien was previously general manager of the company, and Mr. Steel, assistant general manager.

MORE areas in MORE tanks use MONOFRAX® refractories

UNRETOUCHED PHOTOGRAPH taken at United Can and Glass Co., Hayward, California, shows excellent condition of MONOFRAX M lined feeder channel at the entrance end. This pure white material is noted for helping to maintain glass quality.

MONOFRAX M Feeder Channels...

Help guard against glass defects

Seeds, stones, cords and color are minimized when feeder channels are lined with MONOFRAX M fused cast refractories.

Reason: the extreme purity of MONOFRAX M blocks—as well as their almost complete lack of glassy phase. They consist of over 98% alumina, with less than 0.2% impurities.

The dense, granite-like crystalline structure of these refractories gives feeder channels such effective resistance to corrosion that they make a semi-permanent lining. In fact, operators report MONOFRAX channels average less than ½" of cut in three years' service. There's also no need to worry about refractory inclusions being picked up close to the machines.

MONOFRAX shapes are made to close tolerances; are uniform in thickness, and give tight-fitting structures . . . other reasons why this fused cast refractory is becoming *the* most popular lining for feeders.

Find out how the various types of MONOFRAX refractories can help other areas of your tank. Contact: Dept. L-98, Refractories Div., The Carborundum Co., Perth Amboy, N. J.

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Flame Studies: Methods and Results
(*Continued from page 477*)

garding flow distribution in furnaces, especially if the measurements can be repeated after shutdown of the furnace. Because of production reasons, such measurements are generally impossible.

In general, one is forced to study the flow process with small models. They are indispensable when it is necessary to determine rapidly, without going to great expense, structural differences, especially various burner constructions. Thring reports that most larger English steel companies further improve their open-hearth furnaces on the basis of model studies.

Both gases and liquids are used as flow media in cold models. The simplest setup is obtained if one works with air as model substance. The two media, air and gas, which are introduced in a furnace can be designated in various ways in a model. The "gas" can be represented by a stream of air in which smoke, or balsaflour, or even droplets of hard spirit have been uniformly distributed.

In this way it is possible to make the flow of one substance visible and differentiate it from the other. Photography of the flow patterns produced is possible if one makes use of so-called sectional lighting. This is done by shining a flat beam of light parallel to the axis of flow[21]. In this manner the flow pattern can be photographed at several closely spaced planes and one can obtain a general view of the entire flow. Flow visualization of air-operated models is more difficult to accomplish than water-operated models. The advantage of air models is that they enable one to understand more clearly the data for a mixing process. For this purpose, one mixes air, which represents the gas, with traces of gases such as CO_2, CH_4 or NO_2 which can be readily determined quantitatively by physical methods[4, 12, 13].

Radioactive tracer elements were also used for the same purpose. Scheubel[39], on the other hand, represented the gas by a stream of air which had been heated to 40°C and attempted to determine the mixing condition by means of temperature measurements.

The velocity distribution in all these methods is measured with special probes as long as one does not intermix a visible substance, or obtains photographs at fixed times.

A special application of air models is found in the study of flame attack on furnace refractory. Increased corrosion is observed where the gases of the flame locally contact the furnace refractory. This action is brought about in various ways; for example, by active particles which may be contained in the flame, or by sudden locally concentrated combustion which takes place upon gaseous-impact on the refractory and which causes an increase in temperature.

In order to study this process one adds dust of suitable particle size to the model gas and coats the inside walls of the model furnace chamber with an adhesive. The areas which are severely coated with dust are the areas subject to the greatest corrosive attack[22].

Water-operated models enable one to observe flow patterns in a plane as well as in space. For a first orientation it suffices to use an open channel of proper shape, through which water passes at a velocity dictated by

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a wonderland of pure rare earths

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Lindsay's Cerium, Didymium (cerium-free) Salts, Neodymium and other rare earths are widely used to color and decolorize glass. They are available for prompt deliveries in quantities of a pound to a carload.

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the model conditions. Aluminum spangle, which one drops in the water, shows the flow pattern. This method has been found especially useful in the study of flow processes in flues of open-hearth furnaces.

If it is desired to make the flow visible in space one can work with models made from transparent plastic and with the flow visualization method decsribed earlier. Aluminum filings, or better still, aluminum spheres, or air bubbles are introduced in the stream to identify the streams from one another. Colored dyes are used too.

The mixing process can be experimentally determined in a water model. A number of physical properties are available for designating the stream. Kruszewski[4] made use of the electrical conductivity of one material by adding sodium chloride or, better yet, by using a cold and a hot stream, for example, at 20° and 60° C respectively. Furthermore, one can add various chemicals to the water stream whose amount can be determined in a similar manner as gases are analyzed by a physical method. For the velocity determination the same method can be used as in air models. One works either with probes or with photographs made at known time intervals.

Hot Models

Flow and mixing problems in furnaces can be treated in cold models, but the study of heat-transfer processes requires hot models which are more costly. In Ijmuiden an experimental furnace was operated at around 1500° C. The furnace was a scaled-down model of an open-hearth furnace. The linear reduction was 3:1. It was used for studying heat production and heat emission of flames by determining the average flame temperature and emissivity over the entire length of the flame.

A simpler method, which is supposed to serve the same purpose, is the work with a model operating at lower temperatures, which was developed by the English steel industry for the same problem [15, 23, 24]. Conditions for similitude were derived for the model that can operate at around 1000° C. The setup was used for a series of open-hearth furnace experiments. Blast-furnace gas was used.

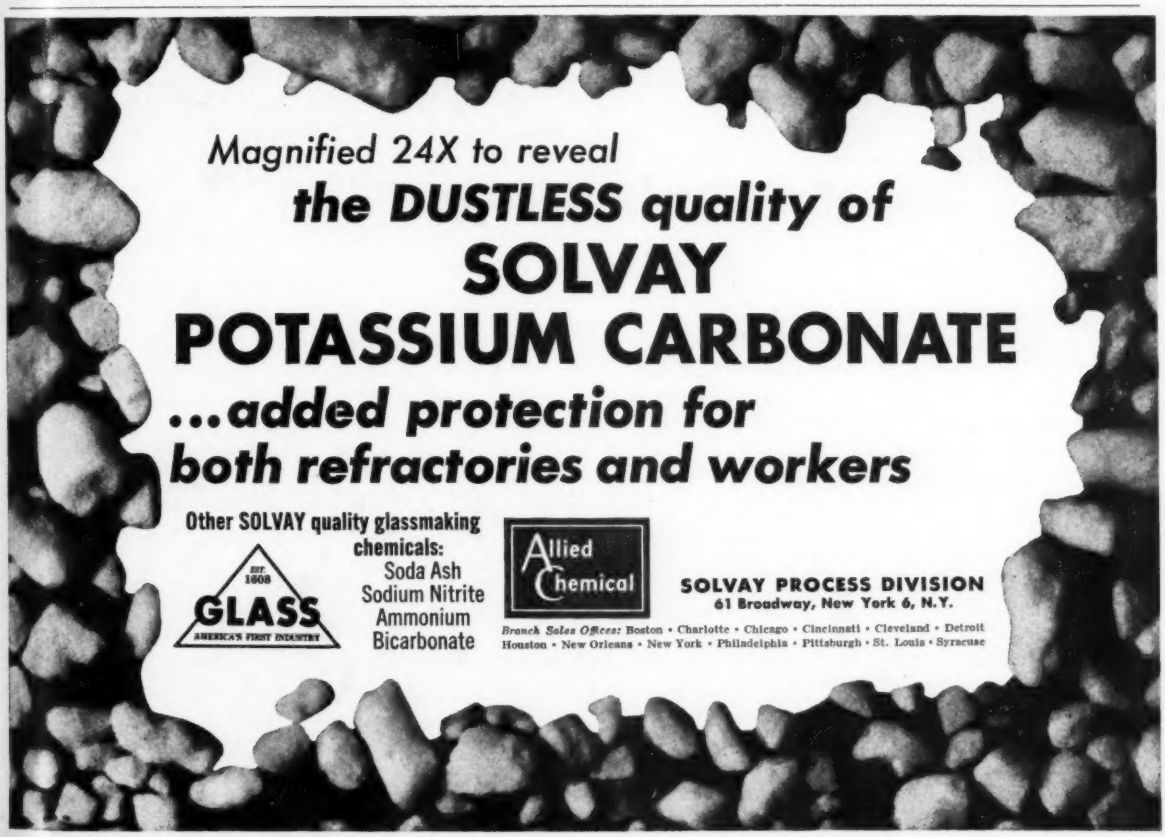
Also included in hot-model studies are experiments with burning distances. For studying burner operations, a scale of 1:1 is used generally.

Mathematical Treatment

A long time ago Heiligenstaedt[18] proposed a method which is supposed to enable one to predict the length of the flame of a burner or the course of combustion along the flame. Heiligenstaedt worked with a burner coefficient K for which he gives values as a function of furnace design.

For example, he gives a K value of 1.5 to 2 for burners made of bricks similar to regenerative burners used in glass-melting tanks, and a coefficient of 4 to 6 for burners with well-defined vortex action. Using this method, it is possible to make only rough distinctions. A systematic application of the conditions in a glass-melting tank is still missing. For this reason, it would be a mistake to pass a negative opinion regarding the usability of this method.

Recently Cude[26] attempted to determine mathemati-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the DUSTLESS quality of
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cally the length of flames by using an empirically determined coefficient K. He worked with an equation which differed from that of Heiligenstaedt in that flame-length was a function of flow velocity and impulse. He states that his results agree well with his experimental results, provided he first determines the coefficient for a given burner length and then subjects the burners to various loads. This method, too, should be looked into in glass house practice.

Among the mathematical methods, Thring's model work [28, 36] is especially interesting. He estimates from simple balance and heat-transfer equations what heating effects will results when one burns a given amount of fuel in burners giving short, or extremely long flames, and flames of varying emissivity. From this he obtains the limiting values between which one should operate in practice.

Results of Flame-Investigations For General Furnace Construction, Especially Open-Hearth

The main theme of all burner studies is the study of the mixing process and especially the determination of the length of flames, position of flame in space (in furnace), and the observation of the heat transfer of flames. After some introductory and general work, we find that Rummel carried out systematic flow investigations on a large scale and pointed out the significance of important parameters which affect it. From his work we learn that an increase in the relative velocity between the two streams reduces the length of the flame, that flames increase in length as the thickness of the individual streams increase, and that flames are shortened at deflection and impact planes. Since then this work has been greatly extended and special attention has been given to the flow in flues and in the furnace chamber of open-hearth furnaces.

These investigations give an excellent orientation of the effectiveness of various burners for open-hearth furnaces and of the effect of individual factors such as excess air, stack draft, flow velocities in the burner, and heating value of fuel, on the length of flame and heat transfer. The position of the flame in the furnace was studied as a function of various operating conditions, and heat transfer conditions were also investigated by means of thermal models and production furnaces.

The work of Chesters and Thring[2], carried out on three open-hearth furnaces of the same steel plants, is worth mentioning. With the assistance of co-workers and a considerable amount of equipment, they attempted to learn more about the intricacies of furnace operation, to establish reasons for fluctuations and compare the modes of operation of the several furnaces.

Important knowledge was gained, for example, regarding the proper burner design or the reason for the excessively large fluctuations in the emissivity of individual flames. In general it was found that the producer-gas flames of open-hearth furnaces are too long and that the heat is not given off to the charge over a sufficiently long period.

For this reason, experiments directed toward shortening the flames were dealt with. Examples of results of an additional experimental series by Newby, Leckie and others[4-11] are illustrated in Figures 5a and 5b. These show the effect of relative velocities of gas and air, and of excess air on flame length.

The figures on the convection currents in open-hearth furnaces, based on model studies by Chesters and Thring, are more impressive. Hansen [17, 30] discusses these original investigations in detail. Fig. 6, an example taken from a number of test runs, shows the convection currents of combustion gases in a so-called Maerz-furnace.

The horizontal sections show the current underneath the roof and in the proximity of the melt. The longitudinal section and the transverse section illustrate the currents in the center plane of the furnace. The specially designed burner produces a very involved flow pattern. The figures show that such complicated processes can also be studied by means of models.

The wear in flues, which is especially disturbing in open-hearth furnaces, has been given special attention in Germany as well as in England (for example, Schulz-Grunow[16]). Open channels were used in this study which gave valuable information for improving the design. Similar investigations of open-hearth furnace roofs were carried out with three-dimensional models (Leys and Leigh[22]).

Results of Investigations of Glass-Melting Tanks

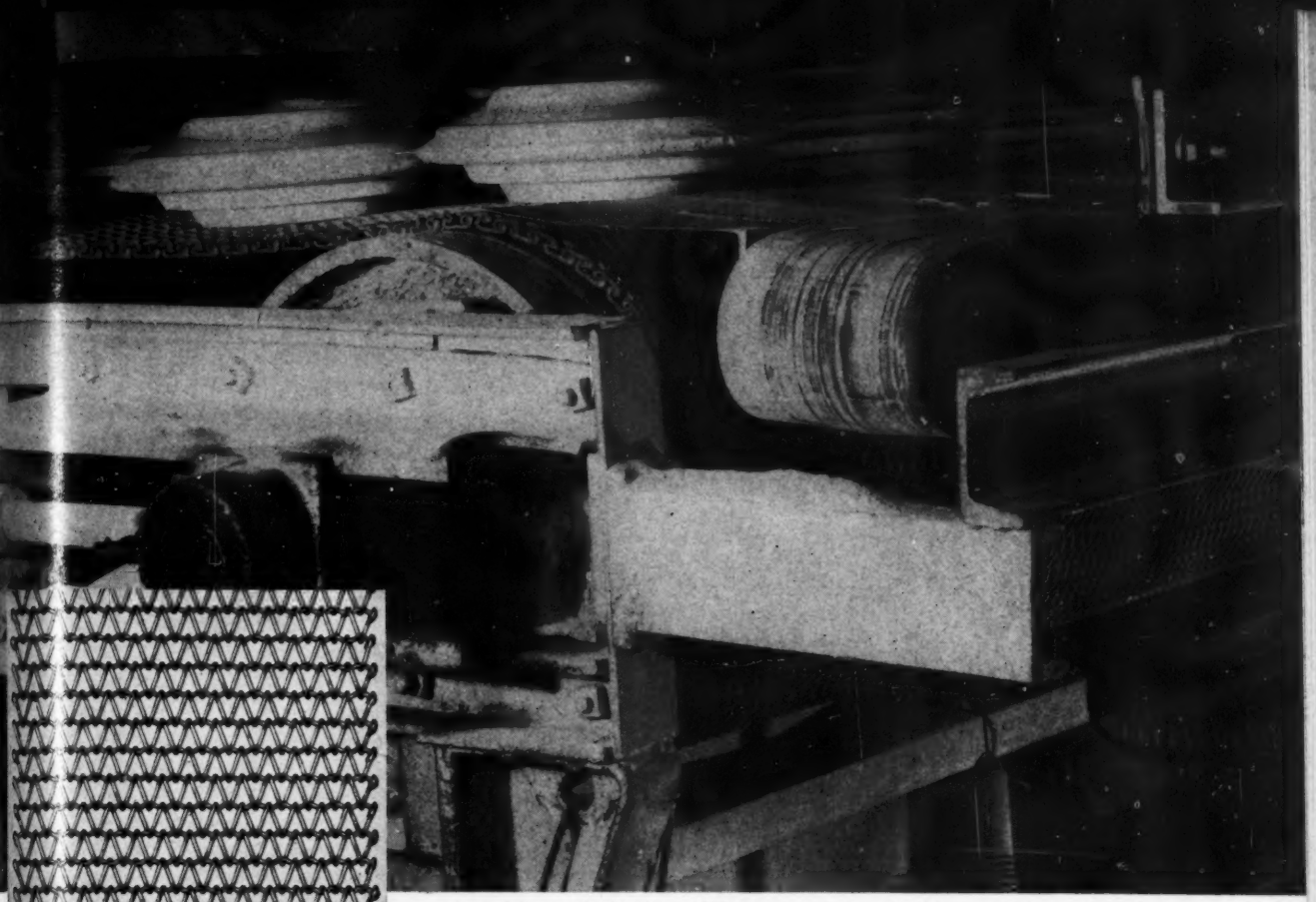
Flame studies in glass-melting tanks thus far have been made less frequently than in furnaces used by the steel plants. One finds only scattered publications in the literature published in Germany, England, Japan and Russia.

More recently attention has been given to flow processes and mixing processes in burners (ports) and in the furnace chamber. These have been investigated by means of models. Above all, the work of Gooding and Thring[32] is the most worthwhile mentioning. They used the production furnace itself as a model.

Using a cold air stream, these investigators determined the flow distribution in the regenerators and furnace proper. They succeeded in making measurements with several burner adjustments during a 12-hour period. Fig. 7 shows the propagation of flames in the furnace. Unfortunately the experimental values can only hold for general orientation since the furnace in question contained no glass and since they did not build in a wooden floor to simulate the glass surface. The individual "flames" could spread out more than is normally the case in a melting tank. However, Fig. 7 shows that this method enables one to make revealing investigations. Unfortunately no similar work has been made known since.

The work of Gooding on flow in regenerators (Fig. 8) is instructive. It shows that the flame impingement on checker work is very irregular. Model similarity is not preserved. In these processes ascensional forces play a role which Gooding could not take into account. Trier[44] showed that the flow distribution in the regenerator of cold furnaces is less favorable than in warm furnaces because buoyancy tends to distribute the rising air stream more evenly in the regenerator. Gooding's ob-

(*Continued on page* 498)



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(*Continued from page* 496)

servations support this. The flow in the regenerator was more uniform as a result of buoyancy.

Practice has shown that the flow through many regenerators is irregular and consequently leads to poorer preheating than in the case of uniform flow. As with Gooding's findings in regenerators, one can predict that the flow distribution in the risers is nearly always irregular. By calculating average velocities, according to the continuity equation, one may subconsciously get the notion that this velocity actually exists at all parts of the regenerator. In reality, one probably never finds a case where the flow distribution in a regenerator is uniform.

Gooding used the production furnace as a model, while Kruszewski[41] worked with a model scaled down 10:1 which was operated with water. He showed the flow distribution and course of mixing in furnaces with two extreme and different burner designs. Fig. 9 shows the difference in the mixing action between the two burners based on numerical data given by the author. The mixing actions in three production furnaces are included for comparison.

The total flame length was used as basis for all presentations (port and tank together) so that the port openings lie at various points on the abscissa. It is surprising that the mixing action of both burners of Kruszewski differs only slightly. An explanation for this is not given in his article.

The question of backflow is also dealt with in the Russian work by Blokh[34]. He finds that up to 30 per cent of the flue gases along the roof of the furnace, and between the flames, flow back to the port. These gases become mixed at the root of the flame and return with the flame-stream. This reduces the flame temperature in an undesirable manner. Thring[33] also feels that high furnace chambers (which increase recirculation backflow) lower the efficiency of the unit. Presumably he too is thinking of the lowering of the flame temperature by the recirculating flue gases, since the increase of the radiating outer surface is probably not significant.

Fig. 11. Eddies at the root of the flame.

Wirbel: Eddy.
Flamme: Flame.

It is conceivable that the detrimental effect is partially cancelled out by the desirable influence of backflow on mixing and firing, but nothing is known regarding this. When despite these considerations there is a tendency to build taller furnace chambers, one probably finds the reason for this in that higher crowns give a better temperature equalization over the width of the furnace, and consequently one may expect a more uniform melting action. The work of Schaubel and Renner, which was recently reported[39], deals with similar questions.

A very undesirable action produced by currents is

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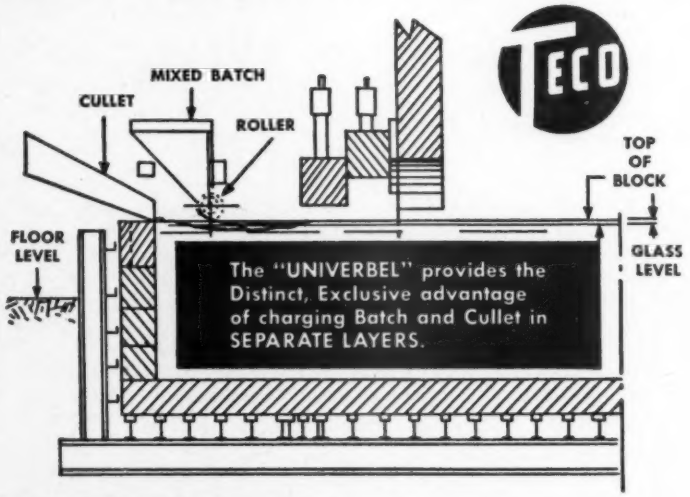

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dealt with by the Japanese, Kunugi[42], Fig. 11. He shows that the small eddies produced at the mouth of the port are essentially responsible for the wear of burners. Furthermore he investigated the action of excess air and of relative velocity of gas and air on flame length and studied the mixing process between gas and air jets issuing freely into space.

Among the industrial observations, Thring's measurements carried out in glass melting tanks—which deal with periodic variations of heat transfer from the flame to the glass—are of interest. The upper curve in Fig. 12 shows the heat radiation of a flame, the lower curve, that of the glass. The difference between the two curves gives the amount of heat transferred from the flame to the glass. The sharp decrease in the lower curve is due to a batch pile. From the curve one can see that the amount of heat transferred to a batch blanket is about 10 times as great as that transferred to the molten glass. The fluctuations of the upper curve are significant for furnace operation; during a reversal period the amount of heat given off by the flame is about 10 per cent lower. According to new work, yet unpublished, by Kahlert, with a radiation intensity meter, the heat given off by the flame during a reversal period was 15 per cent lower at the root of the flame and 5 per cent lower at the end of the flame.

The differences are chiefly a function of the heat discharge processes in the regenerators. One thus understands to what degree the heat transfer is altered during each reversal of the chamber and to what extent the constancy of glass flow is disturbed. These results show

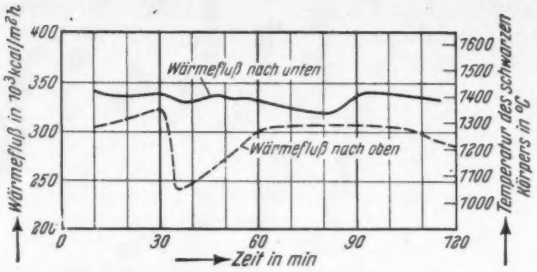

Fig. 12. Heat radiation of flame and of melt in a glass tank furnace. (60-ton furnace heated with producer gas. Pyrometer reading, 1440°C.). The difference in the curves gives the heat transfer from flame to glass.

Warmefluss: Heat transfer.
Temperatur des schwarzen Körpers: Black-body radiation temperature.
Zeit: Time.
Wärmefluss nach oben: Upward heat transfer.
Wärmefluss nach unten: Downward heat transfer.

clearly how important it is to enlarge the chambers in order to achieve uniform preheating temperatures.

Of course the degree to which the chamber is preheated plays a role when the chamber is enlarged, since every improvement in heat utilization in the chamber leads to considerable fuel savings. In many cases one builds the chamber bigger than is warranted from the standpoint of heat utilization. The goal here is uniform preheating. For the same reason, a reduction of the reversal periods to 15 to 20 minutes, and less, is of little importance.

An additional question which is dealt with by Thring concerns the importance of a definite excess of air. In

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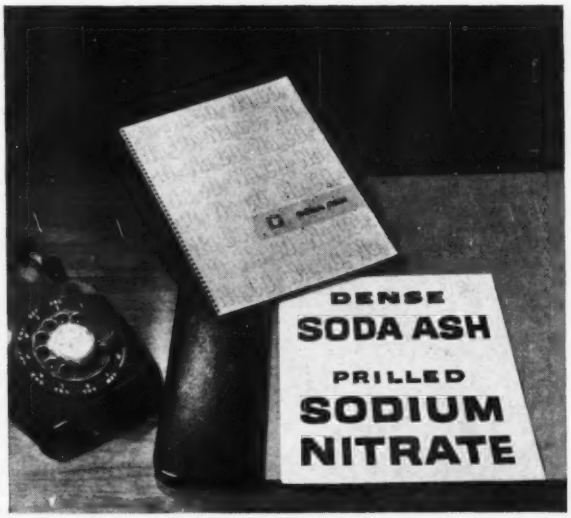

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general the excess air lies in the upper portion of a flame, while the lower portion hardly undergoes complete combustion. Such differences, which can be readily confirmed by analyzing the gases at several points in the outgoing end of the regenerator, impair the economy of the installation. Consequently when making improvements in the burner design one should give consideration to the stratification of the waste gases.

Finally Thring[33] deals thoroughly with the controls of furnaces and shows that truly economical furnace operation is possible only when all important processes can be carefully controlled.

Thring furthermore attempted to correlate the results of thorough measurements, which were carried out on open-hearth furnaces in England, with glass-melting furnaces. To do this, he carried out additional observations on glass tanks and made further calculations. In dealing with insulation of roofs, for example, he showed that the roof receives 50 to 100 times more heat than is conducted away, showing that it acts like a heat reflecting mirror.

Insulating the roof does not noticeably alter the inside temperature; it merely decreases the temperature gradient in the refractory. The temperature on the outside increases. This observation is important to those making evaluations of the suitability of roof insulation.

Thring [36] also shows that an extremely short flame gives off about 80 per cent more heat than a flame whose heat emission is uniform over the entire width of the furnace. Observations in production nearly always show that the flames, especially in producer-gas furnaces, extend into the outgoing ports and even into the regenerator chambers. Thring surmises that a shorter flame than presently used should not have adverse effects on glass-melting operations. The differences which occur in this manner can be greatly equalized by the relatively great height of the furnace chamber (here we have an argument for the construction of tall furnace chambers). It would certainly be extremely interesting to clear up by means of experiments these relationships of present-day furnaces.

Regarding additional observations in the field on flame propagation, the author wishes to mention his work which includes a comparison of the mixing action of three burners. The work on the flame structure and on the lag of the mean value of combustion with respect to the mean value of the mixture is especially worth mentioning since its significance is nearly always ignored[37, 38, 40].

For the purpose of completeness, mention is made of the Russian work of Berman[43] which deals with the calculation of the flow cycle in the gas space between the melting zone and working end. Berman suspects here similar convection currents similar to the glass melt and gives an expression for the determination of the convection; however, he neglects the energy of motion of the individual flames. His results thus give only an approximate orientation. Nevertheless, reference to the currents which are no doubt present is of merit.

Conclusion

Even through careful observation of furnaces with present day tools it is not always possible to explain fully the differences in operational behavior, especially heat consumption in various furnaces. Frequently one can only assume that flame characteristics play a decisive role on the favorable or unfavorable operation of a plant. A systematic examination of all influencing factors is therefore urgently needed. All kinds of preliminary work for such investigations have already been carried out. The experience gained in this work can be applied to glass-melting furnaces, and it enables one to obtain important information regarding furnace operation.

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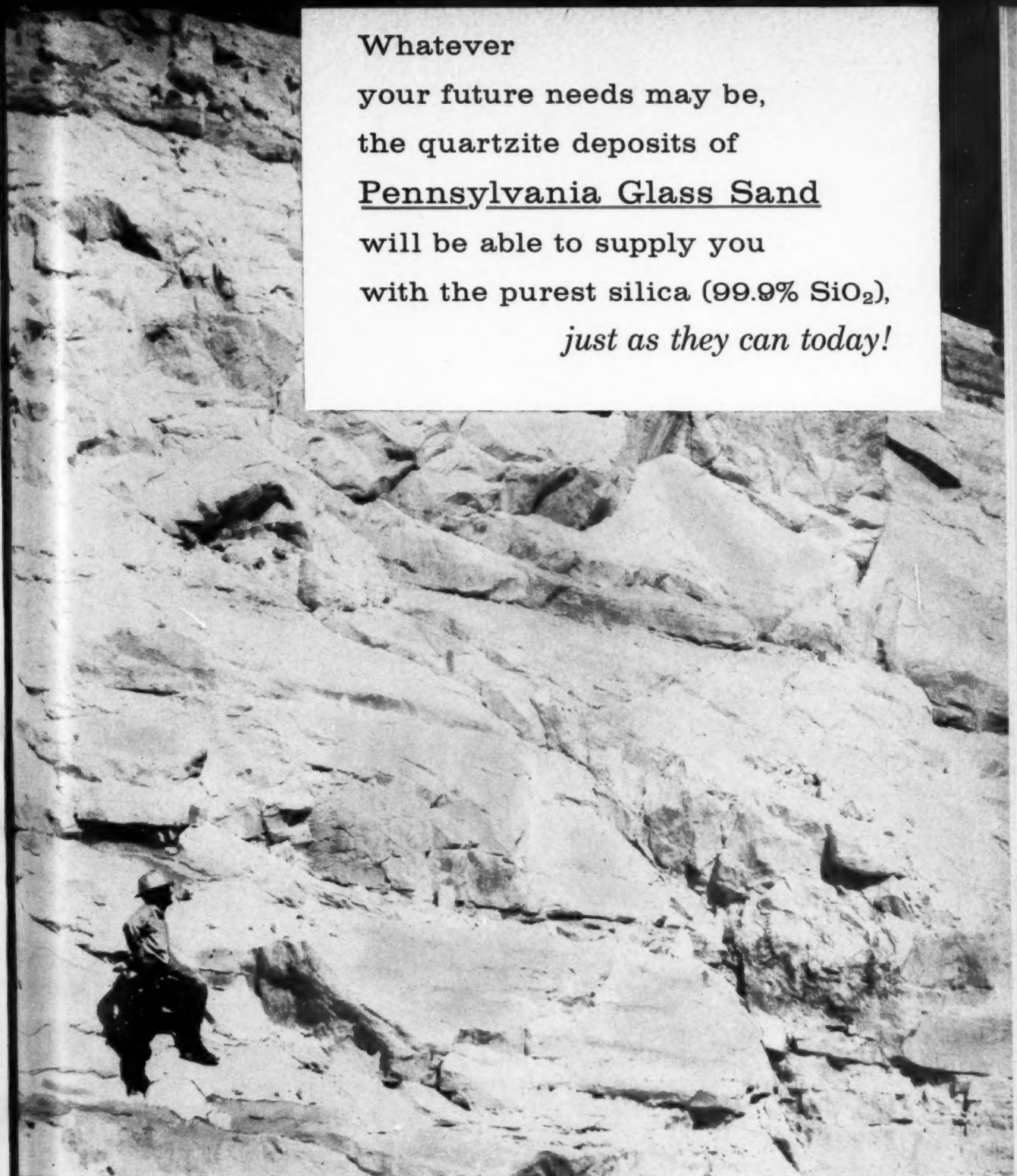

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Corning's New Apparatus Plant at Big Flats

(*Continued from page* 479)

of equipment made from this new Pyrex glass and, in 1919, Corning established its first apparatus plant in New York City. Frederick Kraissl, a veteran German lampworker, and a small staff of glassblowers set up the original shop in a small building on Cortland Street in downtown Manhattan.

One of the four workers under Mr. Kraissl was Herman Schrickel, Sr. who joined Corning's apparatus shop in 1921 to help turn out Pyrex brand laboratory ware.

Need for a plant near the source of its raw materials soon became apparent as business prospered and, in 1923, an apparatus plant was established in Corning, N. Y., with Mr. Schrickel as foreman of the shop. Six years later, he was appointed manager of the apparatus department, a position he held until 1955 when he became assistant to the manager of manufacturing for the technical products division.

Since that time, expansion after expansion has taken place. The post-World-War-II boom in education, industry, hospitals and basic research has evidenced itself by the growth of the Corning Apparatus Plant. From 1940 to 1957, sales of Pyrex brand ware grew some 740 per cent. The first Corning catalog, printed in 1918, had 73 items listed. The 1958 catalog, a hefty 2¼-pounder, has 352 pages and lists some 9200 items of laboratory glassware.

By 1954 the plant had grown, until it occupied six floors of five different buildings. Planning began that year for a modern, up-to-date building that would incorporate all manufacturing processes on one level. Construction on the new plant began in Big Flats, N. Y., July 8, 1957. Manufacturing operations were underway in the plant by February 1958. The Big Flats plant is the ninth to be built by Corning in the past 10 years.

Behind the modern-day innovations and the latest in assembly line processing techniques is the backbone of this new plant—the skilled worker.

The training of these lampworkers is long and arduous, requiring several years of effort, concentration and practice in order to develop the skills of heating, bending and sealing glass into intricate designs that must conform precisely to specifications. The lampworker must have a good sense of proportion and the ability to picture the finished ware even before he heats the first piece of tubing.

The lampworker's lengthy course of training at Corning begins with the simpler operations. During his first year, the worker tries his hand at the easier operations, such as constricting tubes of various types, beading the ends of graduated cylinders and lipping the pouring lip of graduated cylinders.

Then comes a 12- to 18-month training period as a fabricator of simple apparatus items. He carries out the functions of bending, elementary tooling, closing, constricting, blowing and sealing various sizes and shapes of tubing. During this time he is given a chance to show his ability at bending small-diameter tubing, making wash bottle stoppers, setting together stopcocks, and tooling simpler items.

If the trainee shows promise to work behind a blast lamp, he becomes an advanced lampworker. He begins his two-to-three year training in fabricating more complex apparatus ware, using simple blueprints and sample items to guide him in his work. His future advancement from this classification to expert lampworker depends on his dexterity, skill and ability to fabricate the most intricate pieces of laboratory ware, using blueprints to gauge his measurements and shaping.

By the time he becomes an expert lampworker his hands will have acquired the facility of a skilled artisan. and he can begin a lifetime of perfecting his craftsmanship. To him will fall the task of hand-fashioning glass condensers, special retorts and flasks, automatic burettes, and such complicated pieces as fluorine isolation, tetraethyl lead and extraction apparatus.

This same process of training takes place, to a lesser degree, with other skilled artisans at the new Corning plant.

It is through the careful craftsmanship of these workers plus the quality of its Pyrex brand glass that Corning has maintained its position as world leader in the manufacture of laboratory glassware.

Now, with the world's largest building devoted to the manufacture of laboratory apparatus, Corning foresees even greater growth of its business ahead.

Said Paul T. Clark, Corning vice president and general manager of the Technical Products Division, "Historically we have found that the laboratory glassware business varies primarily with gross national product and total national research effort. It is our feeling that

(*Continued on page* 504)

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(*Continued from page* 502)
more impetus than ever will, in the light of events in the past six months, be given to research in the future."

Mr. Clark cited the realization by industry that its business grew at the rate of its new products and new processes, which came out of the laboratory. The military has also recently given added impetus to basic research, as have leaders in education.

"The more laboratories, the more research—and the bigger the market," said Mr. Clark. "We at Corning feel that this collective effort offers a future opportunity that is without parallel. We look forward, in our laboratory glassware business, to a very healthy future."

High Temperature Measurement

(*Continued from page* 481)
resistance furnaces capable of reaching 3000°K and higher.

One such furnace, capable of attaining 3300°K, incorporates a hydraulic press for applying pressures of several thousand pounds per square inch to small samples.[3] The heating element is a long graphite tube which is operated in a protective atmosphere of helium or argon. For thermal insulation, the graphite tube is embedded in carbon black and the assembly is sealed to prevent seepage of gas when the hydraulic press is used. Refractory samples to be studied under pressure are encased in graphite molds (dies) and mounted inside the heater tube which is held vertically between the plates of the press. Under pressure, powdered samples can be formed into dense, predetermined shapes; without pressure, a large number of phase equilibria and rates of reaction among mineralogical and metallurgical materials can be studied.

Among other special-purpose furnaces are a crystal-growing apparatus using a hot-wire type of furnace, and a high-temperature centrifuge.[4] The first of these was developed as a result of unsuccessful attempts to make crystals of tricalcium aluminate for X-ray diffraction by conventional methods. It was concluded that crystals of the desired small size could best be grown from a relatively small volume of melt. The crystals are propagated at the point of a V-shaped loop of fine platinum-rhodium wire mounted under a stereoscopic microscope. As crystallization progresses, the temperature within the droplet of melt can be measured continuously and the crystal growth visually observed.

The apparatus for high-temperature centrifugation of refractories consists of a platinum-wound vertical tube furnace below which is mounted a motor designed to turn at 17,000 rpm. The device maintains samples at 1850°K in a centrifugal field several hundred times that of gravity.

Solar Furnace

One of the more recent additions to the Bureau's high-temperature research facilities is a solar furnace, a device that concentrates the rays of the sun onto a small area where materials can be raised to temperatures up to 3500°C, or about two-thirds the temperature of the sun's surface. Thus far it has been used principally for studies on the vaporization of refractories—materials that can withstand prolonged exposure to high temperatures. Experiments are also being conducted on the use of the solar furnace for the zone-melting method of refining oxides of zirconium, thorium, and uranium. Eventually it may be possible to grow single crystals of these and similar materials for laboratory studies.

For studies of refractories, the tungsten arc, carbon resistor, and electric induction furnaces have the drawback that the electrodes, resistors, or crucibles contaminate the reaction and thus lead to confused results. Because of its "clean" source of heat, the solar furnace avoids these difficulties. In studying the vaporization of refractories the materials can be evaporated directly from a hot spot of known diameter (0.25 in.) to the cool surface of the glass bulb containing the specimen. Furthermore, the atmosphere over the hot spot can be changed without introducing unwanted reactions. On the other hand, there is serious difficulty in accurately measuring the temperature.

The Bureau's solar furnace was converted from a surplus Army searchlight with a parabolic mirror 5 ft. in diameter. The spherical glass around the specimen is placed so that the latter is at the focus of the mirror; the glass itself remains cool because the image of the sun is unfocussed where the light passes through. Light from the sun is first caught by a heliostat, a motor-driven 8-ft.-square plane mirror, by means of an electronic control circuit guided by photocells. The plane mirror is turned so that it follows the apparent motion of the sun across the sky and constantly reflects the light towards the fixed parabolic mirror.

Electric Arcs

The highest sustainable temperatures available in the laboratory are those within the core of electric arcs—values as high as 50,000°K have been reported. One of the newer Bureau programs, sponsored by the Air Research and Development Command, is investigating the processes that take place within such arcs in order to obtain data on chemical equlibria and thermodynamic properties of gases at high temperatures. The work thus far has dealt primarily with arcs of 40 to 200 amperes current which yield temperatures from 10,000° to 20,000°K and can be operated steadily for periods of 10 minutes or more.

In spite of the very complicated detailed mechanism for the conduction of current and heat in an arc, the gas actually exhibits local thermodynamic equilibrium everywhere except in the immediate vicinity of the electrode surfaces. As a result, it is possible to calculate the gas temperatures in the usual sense of the word from gas compositions as determined by spectrographic measurements. Given a complete set of data of this kind over the range of temperatures found in the cross section of an electric arc, one can then calculate many important thermodynamic quantities for gaseous mixtures at the high temperatures of the arc.

Up to the present the work has consisted mainly in the measurement of temperature profiles of arcs in simple pure gases. It is planned next to introduce various solid, liquid, and gaseous materials into the arcs and to study the resulting chemical equilibria by means

(*Continued on page* 506)

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Milestones in Glass Progress

PHOTO COURTESY CORNING GLASS WORKS

1950 In mass-producing TV tubes, the electric sealing lathe, developed in 1950, combines the softening effect of a hot gas flame with an electric arc. The face plate and funnel of a tube are quickly, efficiently sealed with a strong, hermetically tight bond. Formerly, TV bulb-sealing methods relied solely on gas burners.

1890 Michigan Alkali Company, now a division of Wyandotte Chemicals Corporation, was founded by Captain I. B. Ford to supply Soda Ash to the glass industry. Part of its modern Soda Ash facilities are huge, seven-story kilns (shown above), for roasting limestone. Wyandotte is a working partner, supplying technical assistance and raw-material chemicals to those great companies marking milestones in glass progress.

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Founded by a Glassmaker to Serve the Glass Industry

(*Continued from page* 504)

of composition and temperature measurements. It is further planned to obtain transport properties such as diffusion coefficients and thermal and electrical conductivities of gases at the high temperatures prevailing within the arc from data on temperature, composition, current, and voltage. These transport data should give some insight into the effective laws of force between particles in excited energy states.

Differential Thermal Analysis and Thermogravimetric Analysis

Some reactions in solids at high temperatures can be studied by quenching, or cooling very rapidly, to room temperature, and then studying the nature and extent of the reaction in the cooled sample. However, for substances in which reversible transitions or phase changes occur, or in which reactions occur on cooling that cause the sample to disintegrate, the quenching method cannot be used. In such cases the desired information may be obtained by the method of differential thermal analysis. In principle, this consists in heating the sample at a carefully controlled rate and observing the slight deviations from the impressed heating rate due to reactions that absorb or evolve heat. Information about the reactions taking place can then be obtained from the known relations that connect the temperature distribution in the reacting sample, reaction rate, heat of reaction, and thermal diffusivity of the sample. This method has been used to study reversible transitions in solid solutions of the divalent carbonates at elevated temperatures. It has also been applied to oxide systems and mineral polymorphism.

If a gaseous phase is involved in a solid state reaction, the sample weight changes as the reaction proceeds. To study reactions of this type, an apparatus for automatically recording weight changes as a function of time and temperature has been developed. Although limited to a maximum temperature of 1250°C. this apparatus has been extensively employed in studies of the high-temperature behavior of natural and synthetic minerals—oxides, carbonates, phosphates, and others.

The thermogravimetric apparatus is basically a conventional laboratory balance modified so that changes of weight are balanced by adjustment of a magnetizing current. The balancing force results from the interaction of the magnetic field of a solenoid with the field of a permanent bar magnet suspended, inside the solenoid, from one side of the balance. Automatic balancing is achieved by means of a photoelectric sensing arrangement in which a beam of light is reflected to a dual phototube from a mirror mounted on the balance beam. The two sections of the phototube are connected in a bridge circuit, the output of which is amplified and applied to the solenoid. Any change in weight tending to produce unbalance is promptly counteracted by whatever change of solenoid current is needed to maintain balance (within a small fraction of a division of the balance scale). An electronic damping circuit eliminates oscillations and enables the electrical output of the instrument to follow faithfully very rapid changes of weight.

(*Continued on page* 509)

(*Continued from page* 506)

Because of the special advantages of combining the results of thermogravimetric analysis with those of differential thermal analysis, the two sets of equipment have been fitted into a unified arrangement. The output is on a single recording chart which exhibits simultaneously three quantities plotted against time—temperature, change in weight, and the differential temperature.

X-ray Diffraction Studies

X-ray diffraction is the principal technique for obtaining detailed information about the arrangement of atoms in a solid. No two compounds have atoms of the same size arranged in the same way, so that the X-ray diffraction pattern of each compound is characteristic of that compound alone. The spacing between layers of atoms can be measured with an accuracy of 1 part in 10,000, and there is hardly a change—either in composition or spatial arrangement—that is too subtle to be detected.

Thus, by observing the X-ray diffraction pattern of a sample while heating it in a furnace, information is obtained that is useful for: (1) identifying the crystalline phases by comparing with patterns of known phases; (2) detecting changes in phase caused by heat or chemical reaction; (3) measuring the very slight changes in spacing between planes of atoms caused by changes in composition (solid solution formation), thermal expansion, or mechanical stress; and (4) determining the exact arrangement and spacing of the atoms at each temperature.

In 1946, very soon after geiger-counter equipment for detecting diffraction patterns was introduced, the Bureau developed a high-temperature attachment that permits nearly continuous observation of the X-ray pattern while the temperature or atmosphere of the sample is being varied.[5] With the new equipment and the high-temperature attachment, studies that formerly required a week can be made in a day; and transient effects too rapid to be followed by successive photographic exposures (the method previously used) can be studied by scanning a portion of the pattern as frequently as every 2 minutes. Melting, volatilization, chemical reactions, or deposition from the vapor phase can be observed conveniently by scanning back and forth over a single diffraction maximum characteristic of the phase of interest.

One series of Bureau studies utilizing these techniques began with a study of the oxides of manganese. This work was part of a study of fundamental factors affecting the performance of dry batteries. Studies of manganese oxides were then extended to include solid solutions of Fe_3O_4 and Mn_3O_4. In another investigation the thermal decomposition of carbonates heated in various atmospheres was studied with the X-ray furnace and the results were correlated with data obtained by thermogravimetric analysis.

More recently, in a project sponsored by Wright Air Development Center, improved apparatus for accurate measurement of lattice parameters was designed and has been used to measure the thermal expansion of a number of materials being considered for high-temperature applications.[6] The use of the X-ray method for this purpose has the advantage of requiring only 2 or 3 grams of powdered material. From such a sample accurate measurements of the thermal expansion in various directions in the crystal can be obtained. The type of apparatus employed in these studies, with the design improvements developed by the Bureau, is now being used in many other laboratories where high-temperature work is done.

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A Drawn Sheet Glass Process of 1871

(*Continued from page* 482)

systems of drawing glass actually in use. Examination of the designs makes Vallin appear as a perfect furnace constructor.

Thanks to the kindness of M. le Maire of St.-Etienne and to researches made by M. Marc Charras, of St.-Etienne, it is possible to locate Vallin. We hereby thank them.

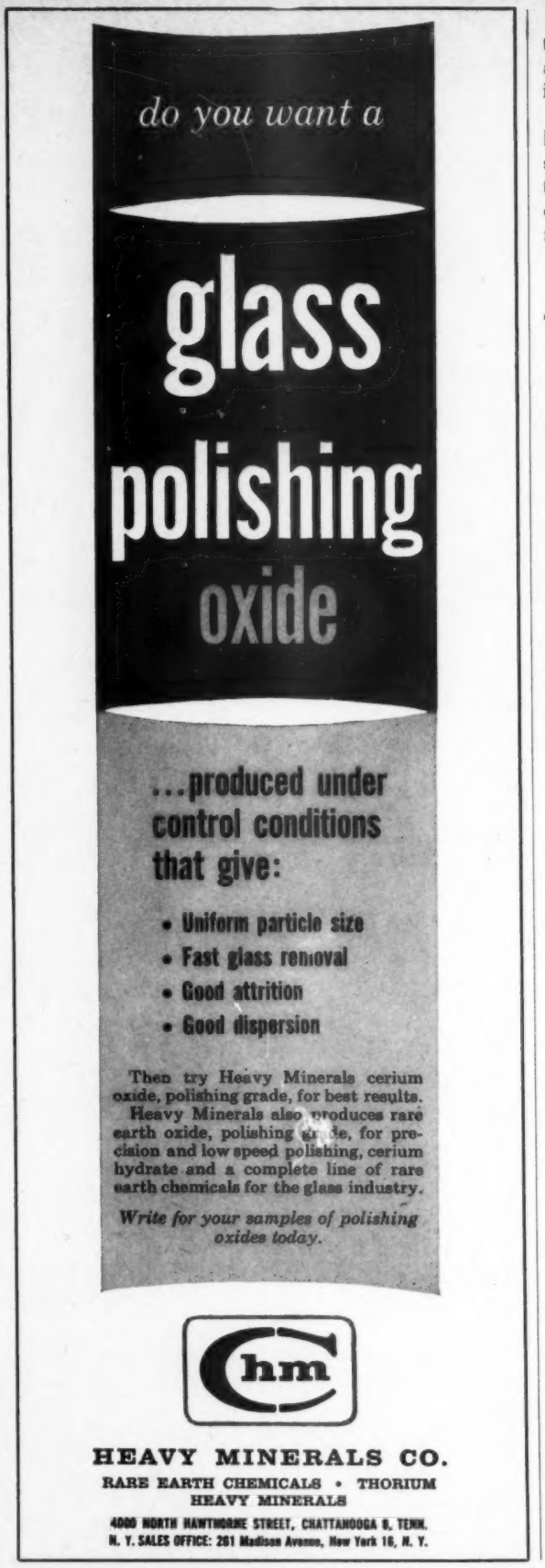
In 1869, a window glass plant was built by Vallin at Givors. Window glass was made there by the process common at the time; that is, in large cylinders, or "muffs," which were blown, then split along one element, and then flattened by reheating in a special furnace. The company name of this glass house was "Vallin, & Vellin & Lapeyre," and then "Vallin & Company." Succeeding names were "Vallin & Lapeyre (1880); "Joseph Lapeyre" (1893); Les Fils Boichot" (1898); and finally, "J. Vallin & Company" up to 1908, when the glass house became the Glass House Souchon-Neuvesel, of Givors.

An associate of Monsieur Vallin (father), Monsieur Joseph Lapeyre, left for Penchot where he organized a window glass plant which eventually became a Glass House of St. Gobain. One of the Boichot sons, from Rive-de-Gier, went to Switzerland about 1902 where he established a glass plant at Moutier (Bernese Jura).

The elder Vallin was therefore a master, a creator. At a time when tank furnaces were unknown, he pictured a system of pots, bringing the refined glass up from the bottom and diverting it into a following pot, to feed a large, elongated pot where he planned to draw "glass without end." Does not this large elongated basin foretell the pot in the Libbey-Owens system, or perhaps the slotted debiteuses, actually?

In the drawing arrangement, we find all the essential elements of the present systems. That is, we find the guides at the edges (f) used actually in the Fourcault system in the form of pincers at the edges, in the Pittsburgh system in the form of slotted bowls or rotating milled wheels, and in the Libbey-Owens system in the form of rotating milled wheels.

In the same way we find the coolers (g) used in all the systems under different forms. We find the elevating rolls (i) in the Fourcault and Pittsburgh systems. We find the Bending roll (k) in the Libbey-Owens system. We find even a second bending roll turning the sheet downward, a system which is not utilized.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In the text of the patent, the description of starting the drawing process is such that we might ask, "How do all of the window glass plants in the world operate, if not in the way that Vallin foresaw?"

Upon reading the Vallin patent, and upon examining his design, we become convinced that Vallin has tried his system. As it often happens, Vallin's ideas preceded the technical possibilities. Possibly also the inertia that operating men offer, today as always, against genuine novelties discouraged this man, who was indeed a genius.

Teen Age Glass Blowers in Business

(*Continued from page* 484)

fore him had been famous as glass blowers for centuries.

Mr. Altier later joined the Rheem company and turned his hobby into the profession for which he is well known today.

American Teens Co. was the first glass blowing firm in Junior Achievement history. Although they had chosen a most difficult business and profession to enter, the young executives met each obstacle with the determination and business acumen so necessary for success in the American tradition.

As a matter of fact, when the Chicago Junior Achievement presented its annual Trade Fair last winter in the Coliseum on Wabash Avenue, the American Teens booth was continually engulfed by teenagers, and adults too, who were fascinated with the youthful glass blowers. And, incidentally, sales at the booth were fourth highest among all exhibiting Junior Achievement companies.

HOWARD WITH MORGAN CONSTRUCTION

Warren H. Howard has been appointed sales engineer, in the Pittsburgh office, of the Morgan Construction Company, Worcester, Mass. He had formerly been associated with the rectifier department of General Electric Company as manager of industrial sales.

JOINS BAUSCH & LOMB

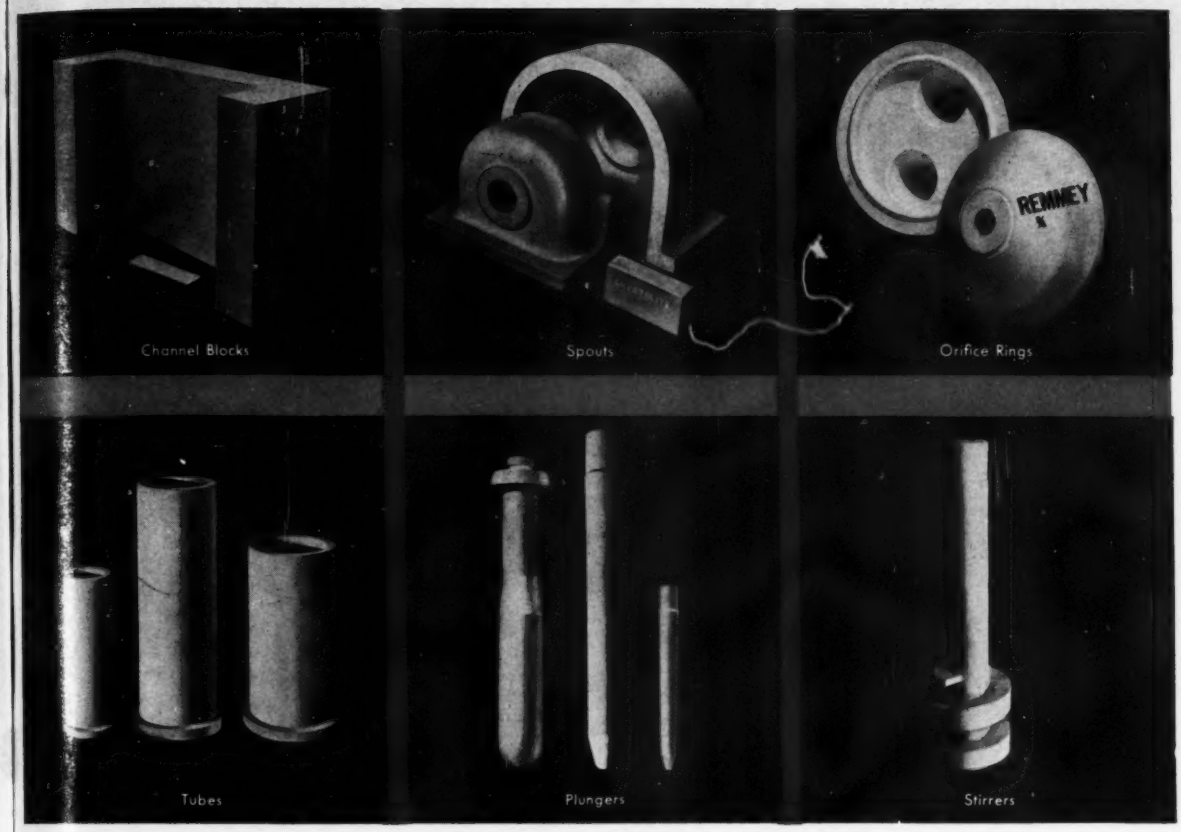
Dr. Dean A. Buckner, a graduate of Penn State and Utah University, has joined the glass chemistry section of the chemical research laboratories, Bausch & Lomb Optical Co., to take charge of studies on infrared transmitting materials.

NEW RESEARCH GROUP FOR CORNING

Corning Glass Works has established a new group to coordinate glass melting research, development and service activities. At the same time, three new department managers have been appointed by Dr. William H. Armistead, company vice president and director of research and development.

Dr. Ben Allen has been named to the newly created post of director of melting technology in the research and development division; Dr. Charles A. Bradley, Jr., succeeds Dr. Allen as manager of melting research; and Robert C. Cleveland has become manager of Pilot Plant 1.

Other staffs which will be consolidated in the new melting technology group are the departments of chemical services, glass technology and furnace engineering.



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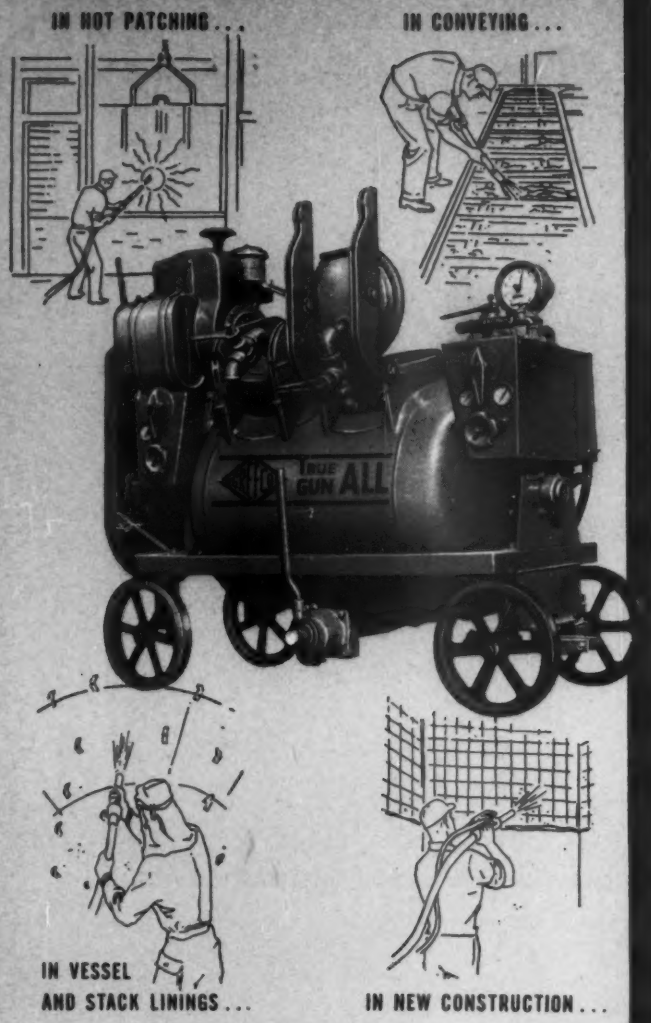

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Inventions and Inventors

(*Continued from page* 486)

This invention relates to a method of bending and tempering flat plates of glass. More particularly the invention relates to bending and tempering glass plates which have more or less pointed ends with deep or sharp bends, such as are used for the rear windows or lights in recent models of automobiles.

The elongated glass plates or blanks are bent almost to their final, desired shape through the action of localized heat on the glass while it is balanced on a male bending mold. Then after the bent plates have been cooled on the bending molds sufficiently to permit safe handling they are inverted and placed on female tempering molds which support the bent plates around their peripheries. The bent plates, supported on the female tempering molds, are introduced into a second furnace, heated evenly, and then tempered by chilling.

There were six claims and 11 references cited in this patent.

Glass Wool and Fiber

Apparatus for Making Coated Fiber Glass Strands. Patent No. 2,800,761. Filed November 12, 1953. Issued July 30, 1957. Four sheets of drawings; none reproduced. No assignee. By Robert Stuart.

This invention relates to apparatus for making coated fiber glass strands, such as may be useful for making filter cloths, woven fabrics, cords or ropes, fillers for articles of clothing, among other items.

The apparatus provides a means for feeding a plurality of unsized or desized fiber glass strands, a liquid elastomeric coating bath through which the strands travel, a drying or vulcanizing chamber through which the coated strands travel in converging paths, a strand-twisting device rotatably mounted near the discharge end of the drying or vulcanizing chamber. The device is power-driven and causes the coated strands, while still moldable from partial drying, to be twisted together inside the drying or vulcanizing chamber. Means for winding up the multi-ply strand composed of the inter-twisted coated strands are also provided.

There were seven claims and 13 references cited in this patent.

Sheet and Plate Glass

Edge Finishing Method and Apparatus. Patent No. 2,795,086. Filed November 21, 1952. Issued June 11, 1957. Two sheets of drawings; none reproduced. Assigned to Libbey-Owens-Ford Glass Company by George Vincent Clark.

This invention relates to the edge finishing of pattern cut glass sheets or the like. More particularly, it relates to a method and apparatus for simultaneously finishing opposite edges of said sheets as they are moved in a predetermined path.

According to this invention, a sheet of pattern cut glass or the like, or sheets of the same in a safety glass "sandwich," having substantially parallel opposite sides or edges is caused to be passed between finishing elements to simultaneously treat both of said edges in the manner desired. In particular, the sheet or sheets are supported on a movable carriage from which said edges

project and which carries said sheets in a predetermined path. Finishing elements are supported outwardly and at both sides of the carriage so as to be swingable into the path of the edges of the sheets as they are moved on the carriage past said elements. Power units are provided for each of the finishing elements such that they may be urged into yielding contact with the opposite edges and hold the same in properly disposed position as said edges are treated simultaneously.

There were two claims and the following references cited in this patent.

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Tube and Cane Machines

Method of exhausting lamps. Patent No. 2,812,228. Filed May 13, 1954. Issued November 5, 1957. No sheets of drawings; none reproduced. Assigned to Westinghouse Electric Corporation by John F. Gilmore and Thomas H. Heine.

The present invention relates to exhaust and, more particularly, to a method of exhausting fluorescent lamps.

During the exhaust of fluorescent lamps on an exhaust machine one of the defects encountered is the contamination of the sweep (a pipe extending from the exhaust head to the rotary portion of the exhaust valve) by deleterious gases which have been pumped out of the lamp and remain in the sweep immediately prior to the gas-filling position. In the present automatic exhaust machine these contaminants are pushed back into the lamp by the fill gas at the gas-filling station.

Another defect of the present exhaust practice is the failure to prevent "slow leakers" which have not been pinched off, from contaminating the fill gas line and thus adversely affecting the quality of the lamps.

It has been found advantageous to pinch the lamp off and to flush the sweep (prior to the gas-fill station) to remove any contaminants remaining in the sweep. The invention also proposes that after the flushing operation the sweep alone be filled to a predetermined pressure at the sweep-filling station. When the filled sweep has indexed beyond the gas-fill station, the pinch clamp can be reopened thus filling the lamp. Thus a "slow leaker" is isolated from the fill-gas system and cannot contaminate the fill gas and adversely affect the quality of succeeding lamps indexing into the fill station.

Miscellaneous Processes

Fibrous Glass Mats and Manufacture Thereof. Patent No. 2,801,673. Filed January 4, 1954. Issued August 6, 1957. No drawings. Assigned to Owens-Corning Fiberglas Corporation by Paul L. Welsh.

This invention relates to fibrous glass mats and, more particularly, to fibrous glass mats made by intermingling mass accumulations of fibers in both continuous and discontinuous form.

The mat produced according to this invention is essen-

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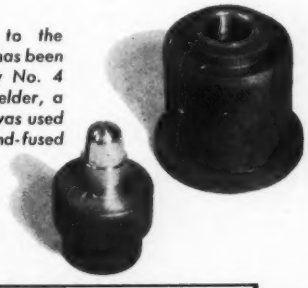

The plunger shown, mate to the Colmonoy-protected thimble, has been hard-surfaced with Colmonoy No. 4 also. The Colmonoy Spraywelder, a powder metal spraying unit, was used to produce the sprayed-and-fused overlay. The two parts, with similar long wearing surfaces, provide the ultimate in wear resistance.

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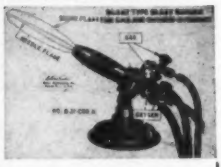

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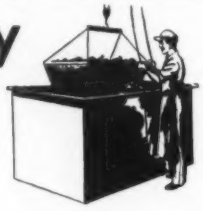

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tially a mat of individual, discontinuous glass fibers reinforced by strands or yarns of glass fibers randomly distributed throughout the thickness of the mat, but concentrated in the center and gradually diminishing toward the outer layers.

Thus, another feature of the invention is the fact that another variable, namely yarn-density distribution through the thickness of the mat is added to the controllable factors in the manufacture of mats, thereby making it possible to produce fibrous glass mats having a wider range of properties.

There were 17 claims and the following references cited in this patent.

2,528,091, Slayter, Oct. 31, 1950; 2,635,301, Schubert et al., Apr. 21, 1953; 2,639,759, Simison, May 26, 1953; 2,704,734, Draper et al., Mar. 22, 1955.

THATCHER ENTERS LIGHTING FIELD

Thatcher Glass Manufacturing Company, McKee Division, Jeannette, Penna., has appointed Hugh Claspy as its representative for illuminating wares. This appointment marks the entrance of Thatcher into the lighting field of the glass industry.

PATTISON, V. P., HOUZE GLASS

Robert M. Pattison, formerly comptroller, has been appointed vice president and general manager of the Houze Glass Corporation, Point Marion, Penna. He succeeds John L. Alpert who recently resigned as executive vice president.

CHARLES E. MASKREY

Charles E. Maskrey, who retired earlier this year as midwest sales manager of Knox Glass Incorporated, died July 16 as a result of a heart attack. He had been associated with Knox in various sales capacities since 1924.

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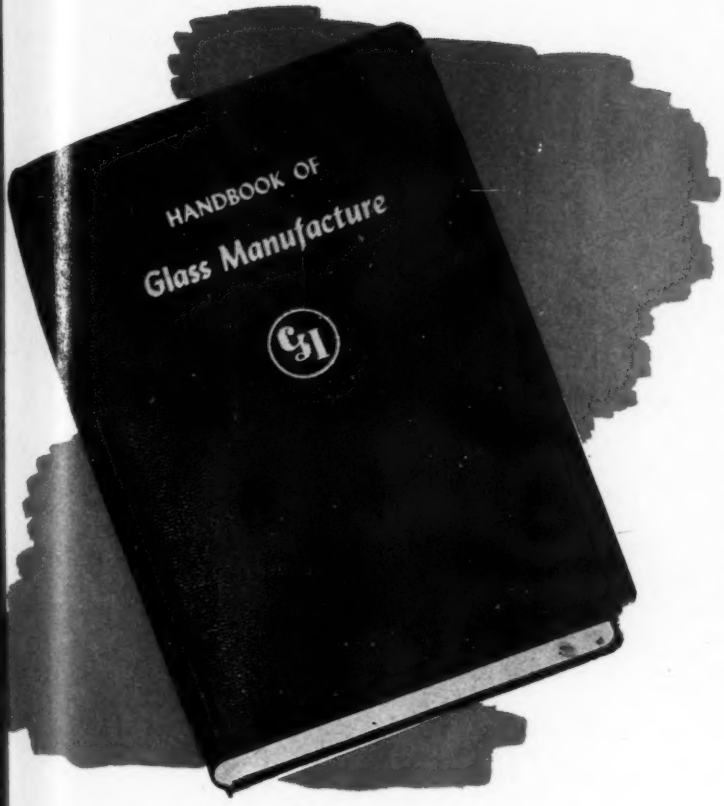

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